

Predicting Soybean Rust Epidemics Using Meteorological Trajectory Analysis and Aerobiological Information

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Soybean Rust Meeting

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Aerobiology

Aerobiology is often considered the “microbiology” of the atmosphere. It is the study of the movement of biological particles (bioaerosols) or products of organisms within the atmosphere or within the indoor environment.

By its very nature, the field of aerobiology is interdisciplinary with meteorology and aerosol physics at its core and with applications in the fields of agriculture, plant pathology, allergy, public health, immunology, palynology, biochemistry, and microbiology.

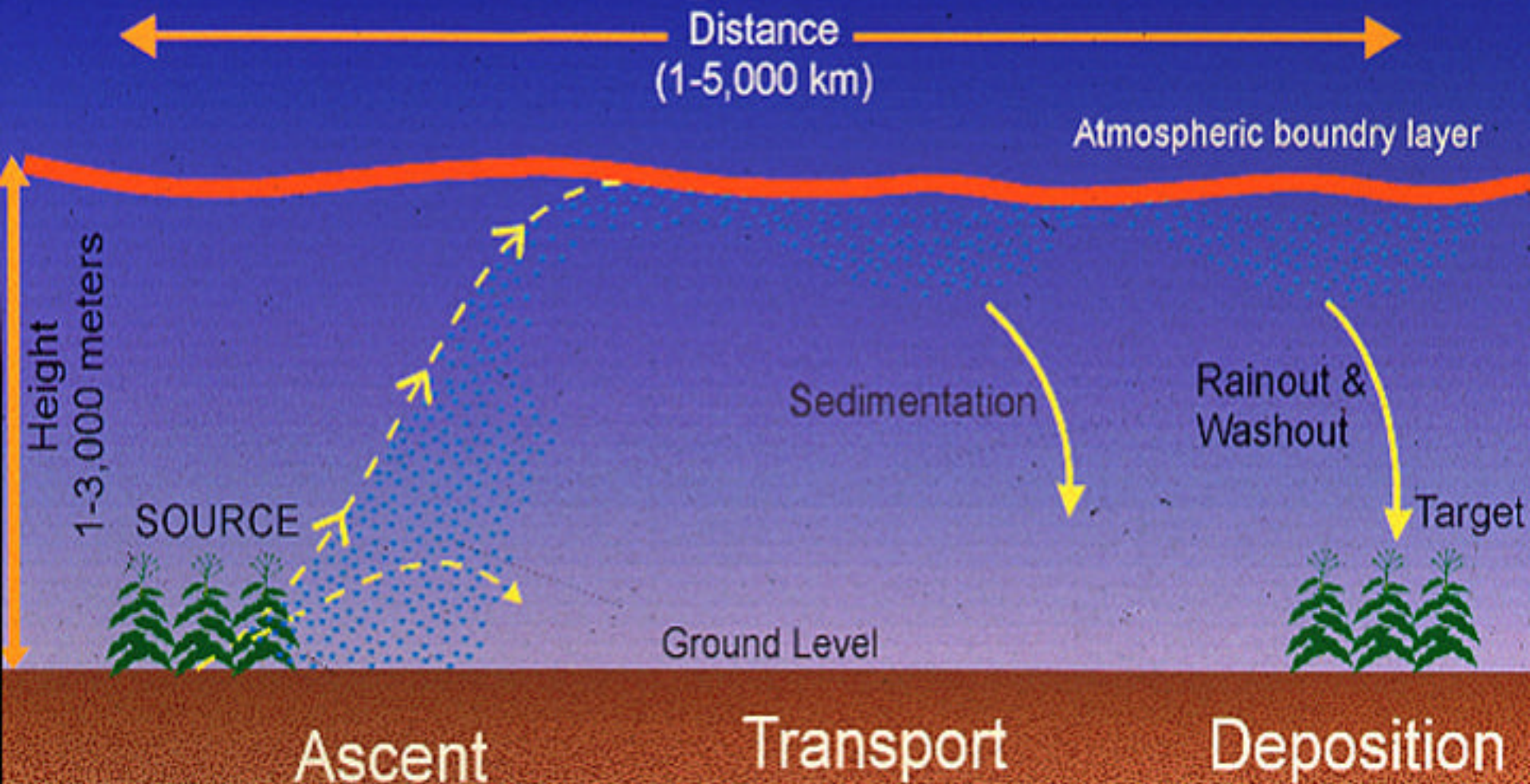
Definition of **BIOMETEOROLOGY**

BIOMETEOROLOGY is an interdisciplinary science studying the interactions between atmospheric processes and living organisms - plants, animals, and humans. It concerns the process-response system of energy and matter flows within the biosphere.

DEFINITION of a Plant Disease Epidemic

The dynamic biological process that occurs when a population of the pathogen (spores, etc.) attacks a population of hosts (fields) over time (days, weeks) and space (km, miles) as influenced by environment (temperature, leaf wetness, winds, etc.) and the actions of growers (fungicides, varieties, cultural practices) resulting in losses in yield and quality of the agricultural product.

Atmospheric Transport of Spores



A Weather-Based Assessment of Soybean Rust Threat to North America

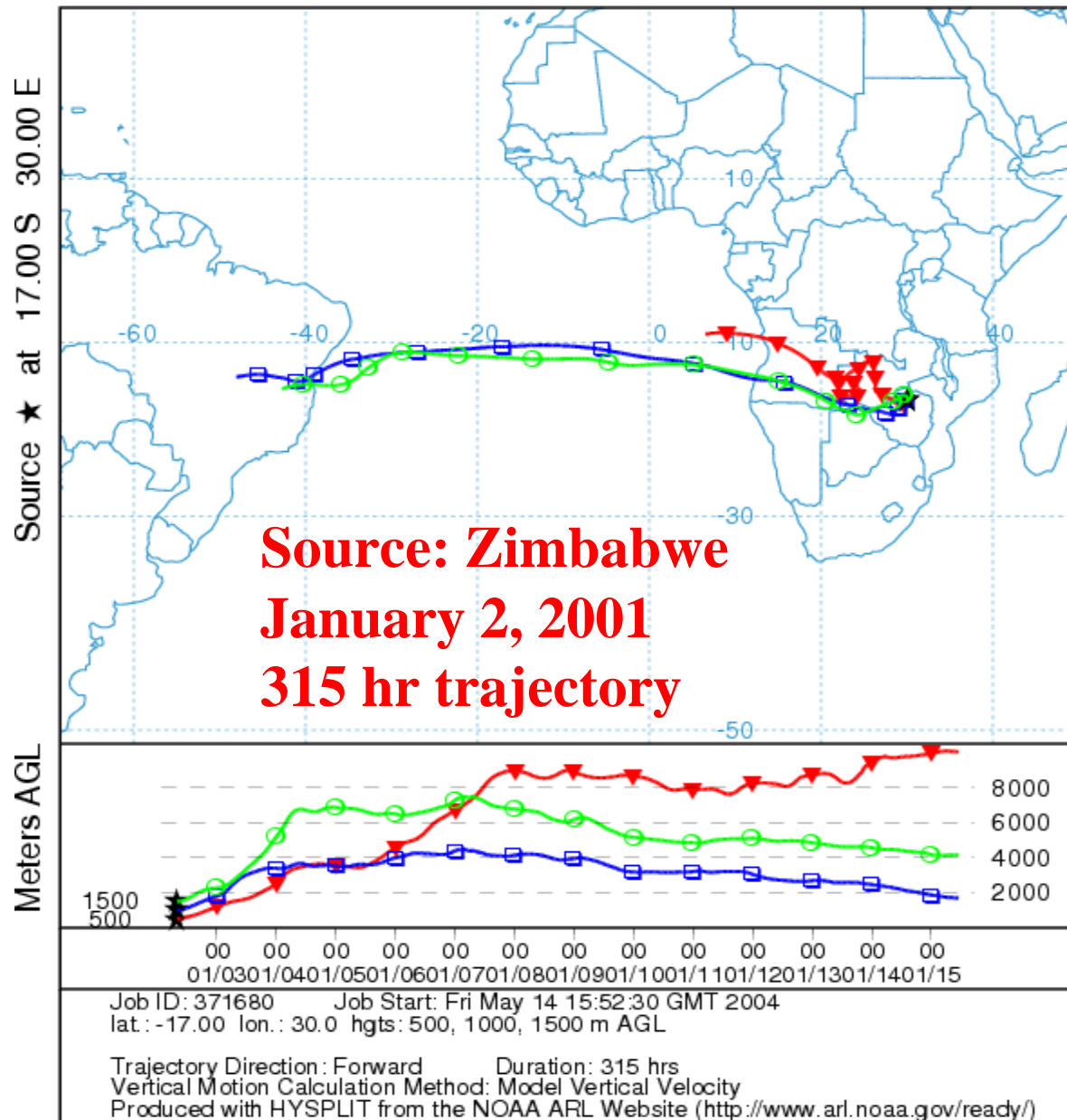
North Carolina State University

USDA APHIS / CPHST

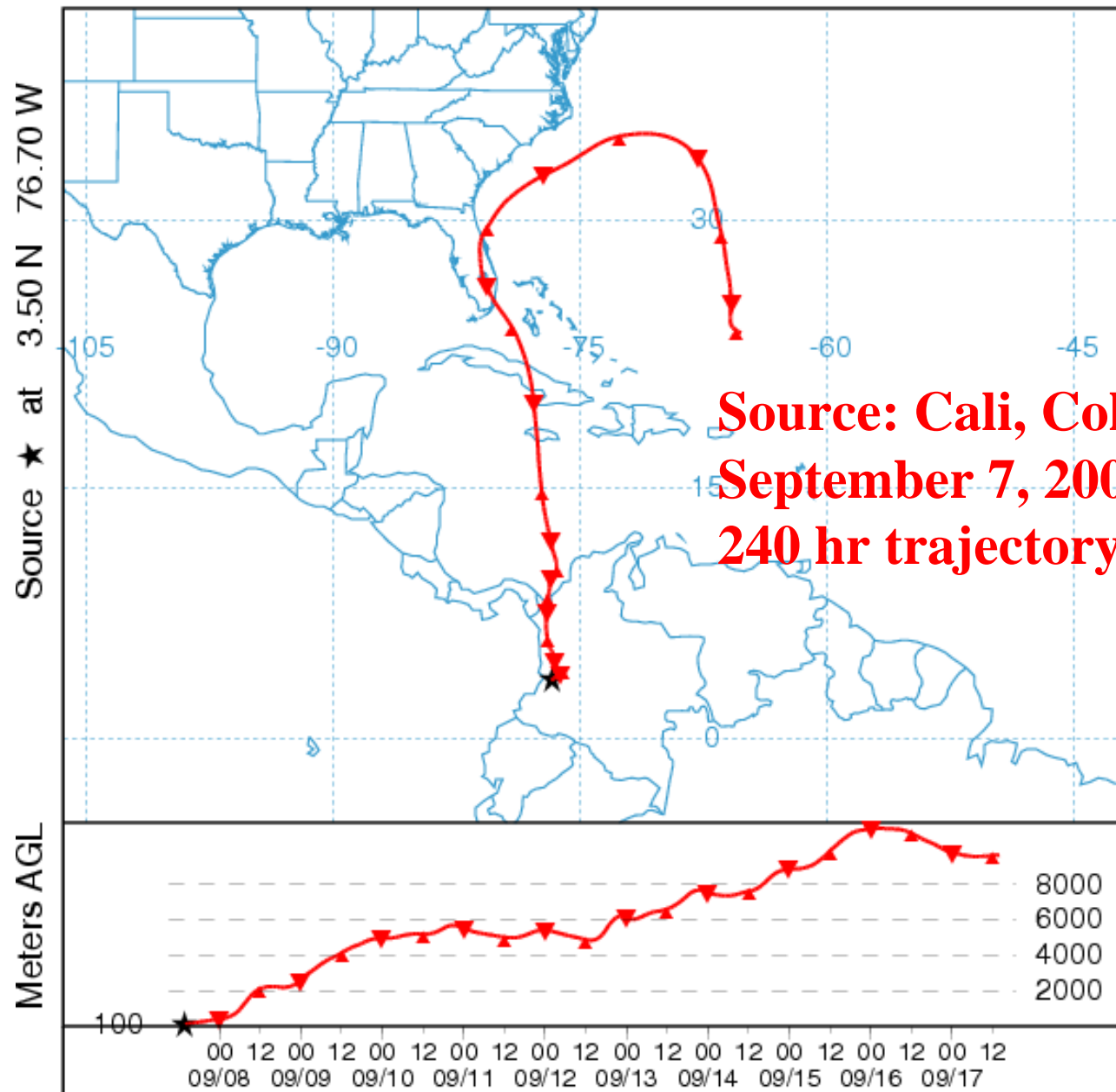
Penn State University

ZedX, Inc

NOAA HYSPLIT MODEL
Forward trajectories starting at 08 UTC 02 Jan 01
FNL Meteorological Data



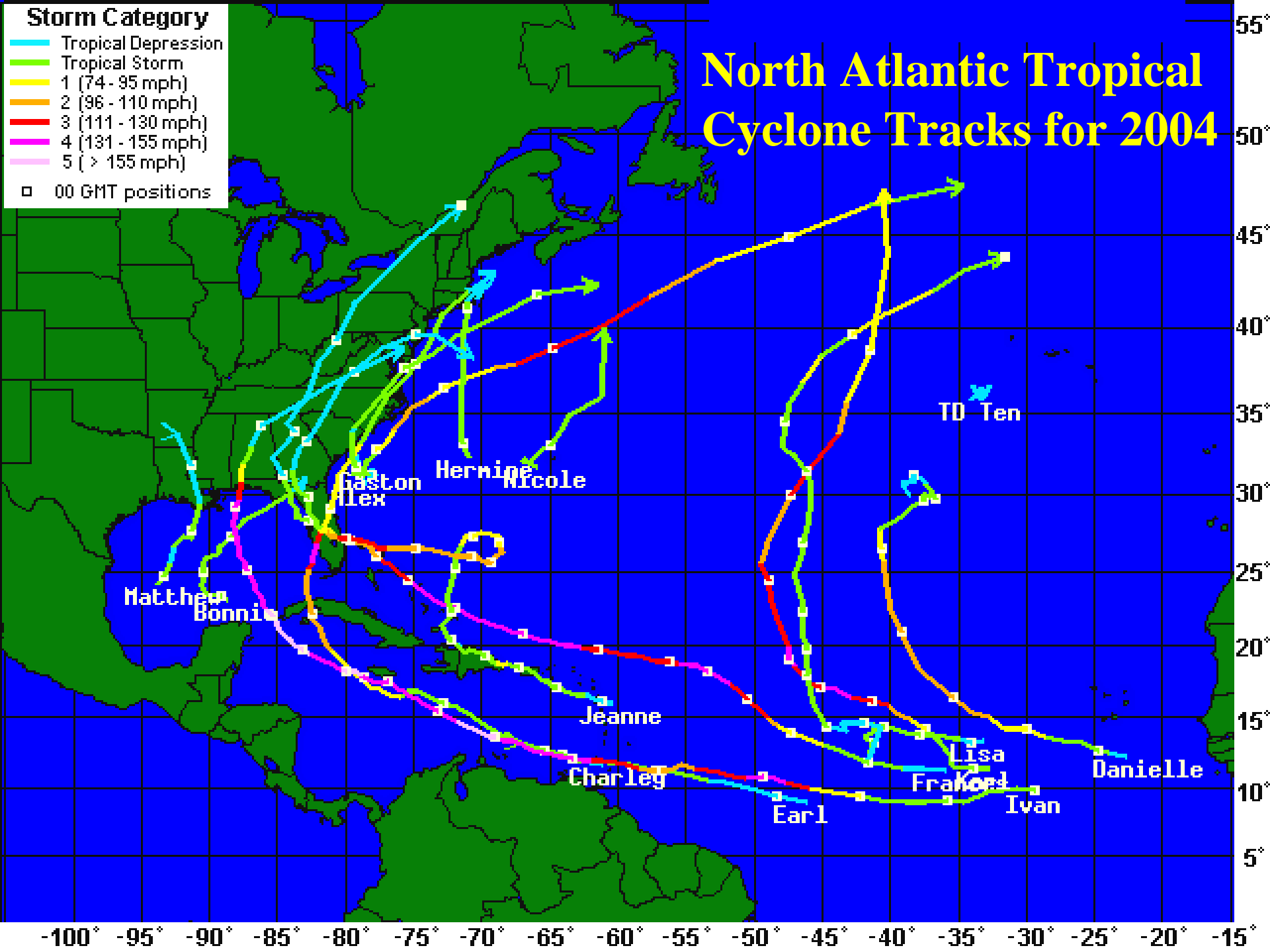
NOAA HYSPLIT MODEL
Forward trajectory starting at 14 UTC 07 Sep 04
FNL Meteorological Data



Storm Category

- Tropical Depression
- Tropical Storm
- 1 (74 - 95 mph)
- 2 (96 - 110 mph)
- 3 (111 - 130 mph)
- 4 (131 - 155 mph)
- 5 (> 155 mph)
- 00 GMT positions

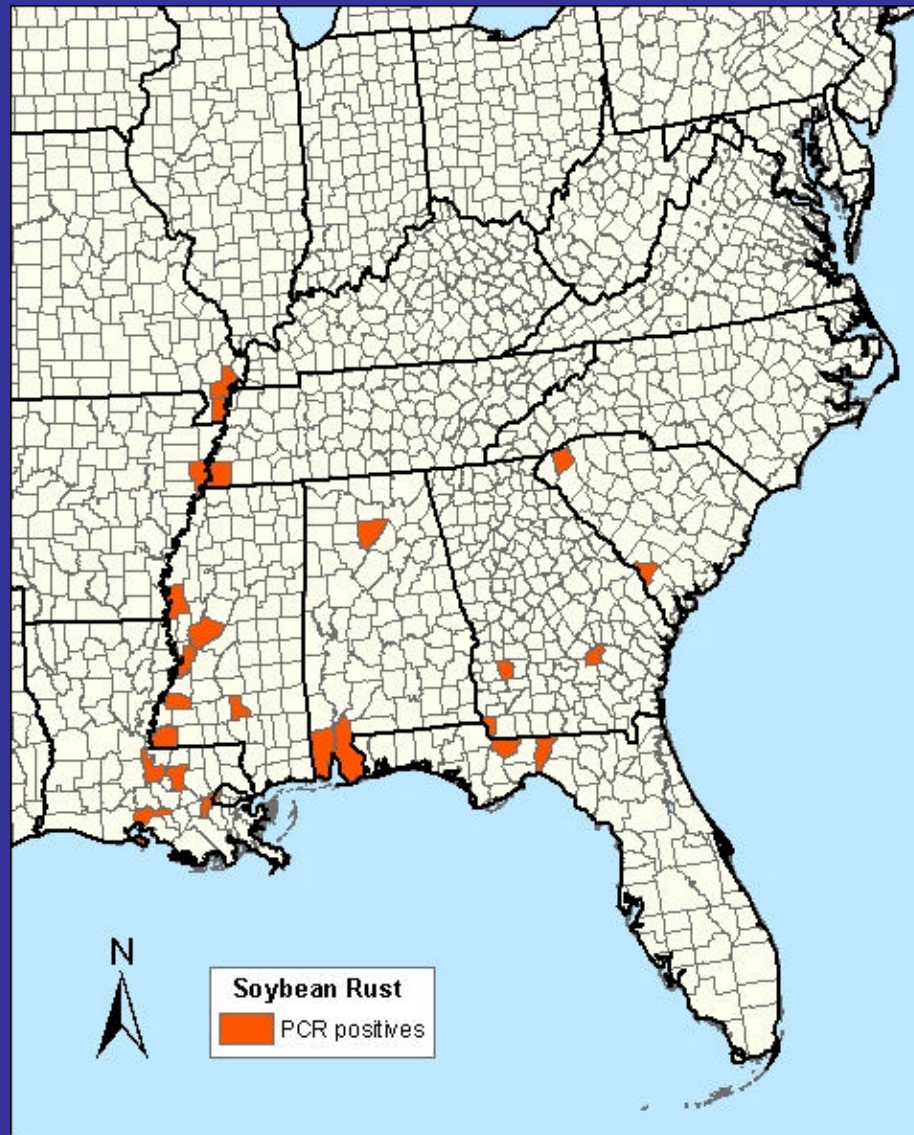
North Atlantic Tropical Cyclone Tracks for 2004



2004 Tropical Weather Systems	Interaction with trajectories	Likelihood of spore transport reaching United States
Hurricane Alex	None	None
Tropical Storm Bonnie	Highly Unlikely	Highly Unlikely
Hurricane Charley	Highly Likely	Highly Unlikely
Hurricane Danielle	None	None
Tropical Storm Earl	None	None
Hurricane Frances	Highly Likely	None
Tropical Storm Gaston	None	None
Tropical Storm Hermine	None	None
Tropical Depression 10	None	None
Ivan	Highly Likely	Distinct Possibility
Jeanne through Nicole*	None*	Highly Unlikely / None

Table 1: 2004 Tropical weather systems and their potential impact on atmospheric transport of soybean rust spores from South America to the continental United States

SBR Detections in US - 2004



NORTH AMERICAN PLANT DISEASE FORECAST CENTER

SOYBEAN RUST

BLUE MOLD

CUCURBITS

SOYBEAN RUST



6 Apr 2005

April 05						
S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

Welcome to Soybean Rust

Forecast Homepage

[15 March 2005 - Special Notice - Please Read](#)

Welcome to the Soybean Rust Forecast homepage for 2005. The forecasts will be generated on Monday, Wednesday and Friday each week from March through October. Timely information on the occurrence of soybean rust and the future movement of inoculum (fungus spores) across the North American continent is important to soybean producers in managing this destructive and fast-moving plant disease epidemic.

Epidemic Update

03/23/2005

Soybean Rust has been confirmed in Hernando County, Florida. Disease was observed earlier this month on old-foliage kudzu, then again on March 21 in the same area. Samples from the earlier observation were just recently confirmed as SBR. The most recent observation is on new growth. We will use the trajectory starting point in Pasco County to represent any existing disease in both Pasco and Hernando County, as they are adjacent to one another. Please consult our [current forecast](#) for the potential of epidemic spread.

Current Forecasts

How to Read the Forecasts

Interesting Links

Do You Have Soybean Rust?

Management of Soybean Rust

Reporting Soybean Rust

Threat and Risks

Where Did It Come From?

Educational Material

Sponsors

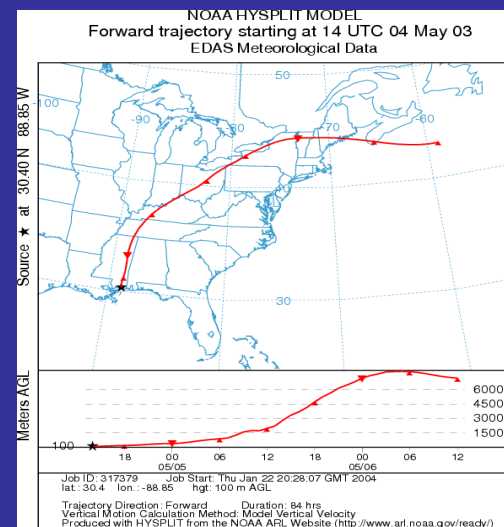
Network Coordinators

Glossary

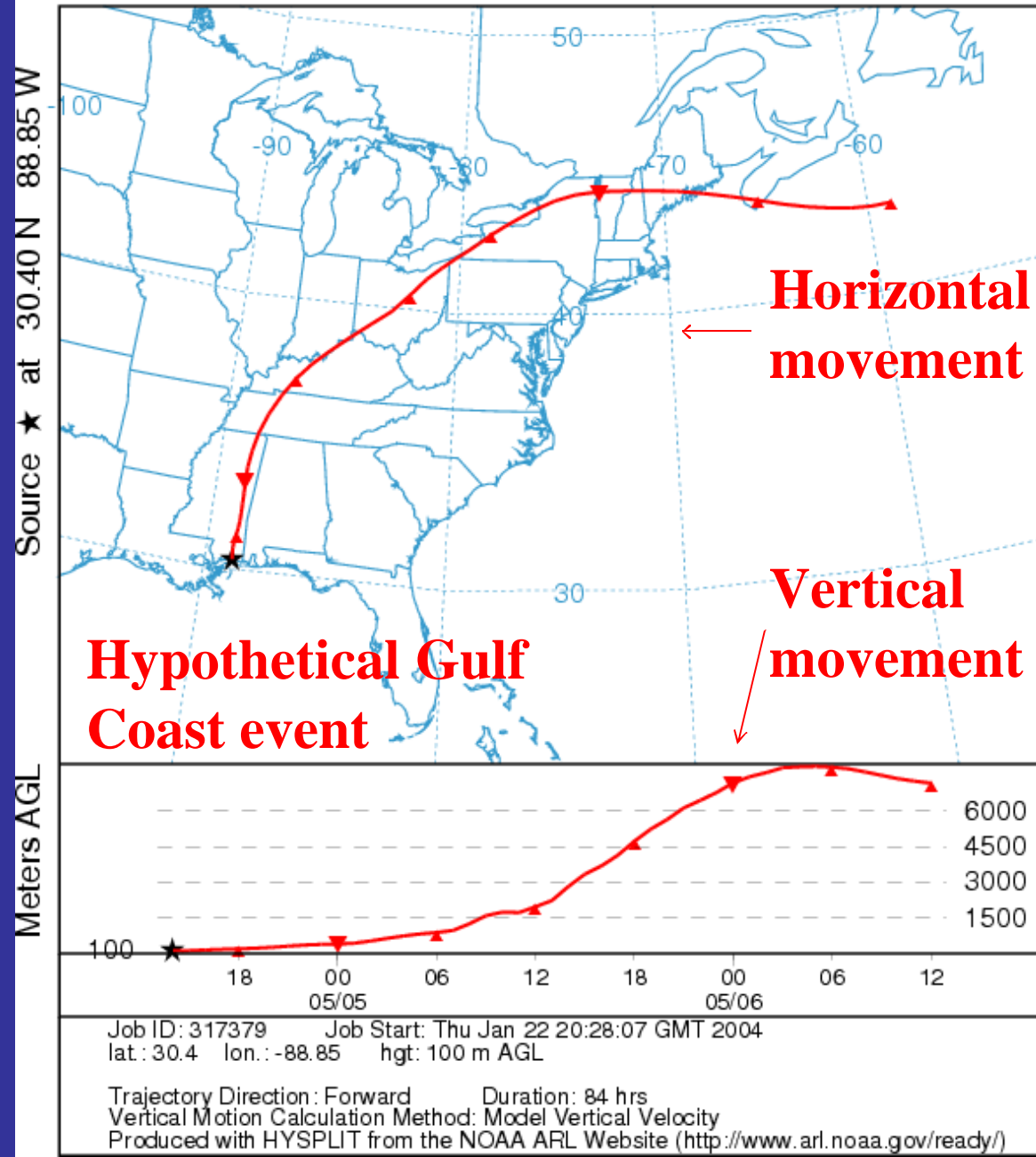
Contact Information

HYSPLIT IN THE TRAJECTORY MODE

In trajectory mode, the output is a line or curve on a map. Each atmospheric trajectory represents the forecast time-space pathway that the center of a cloud of airborne particles would take when released at a given location, day, time, and vertical elevation(s).



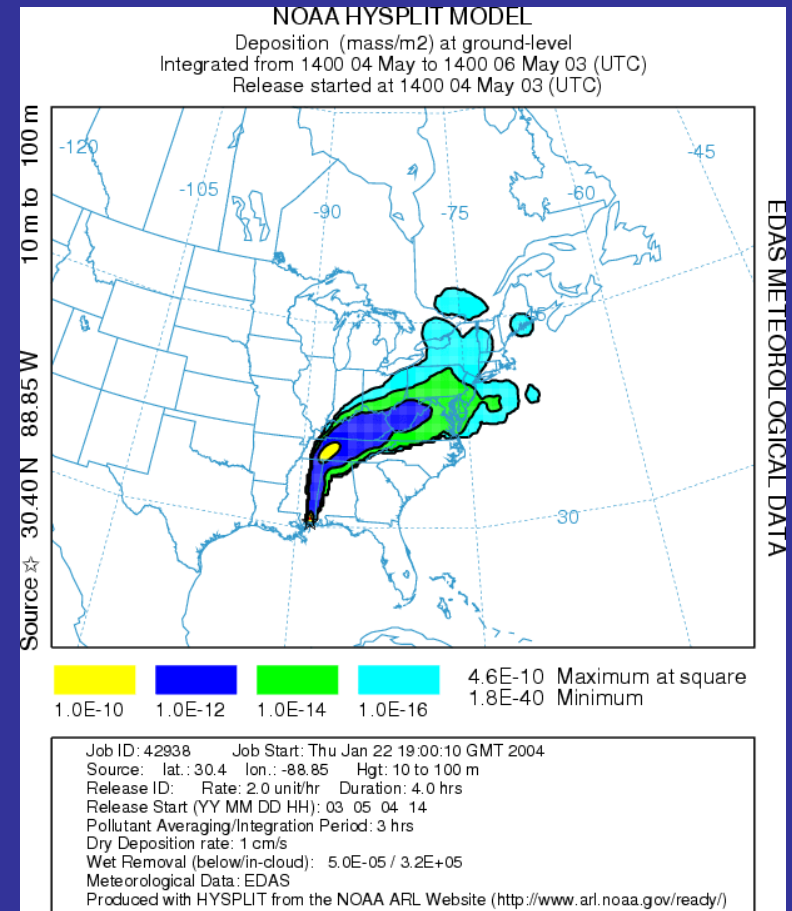
NOAA HYSPLIT MODEL
Forward trajectory starting at 14 UTC 04 May 03
EDAS Meteorological Data



HYSPLIT IN THE DISPERSION MODE

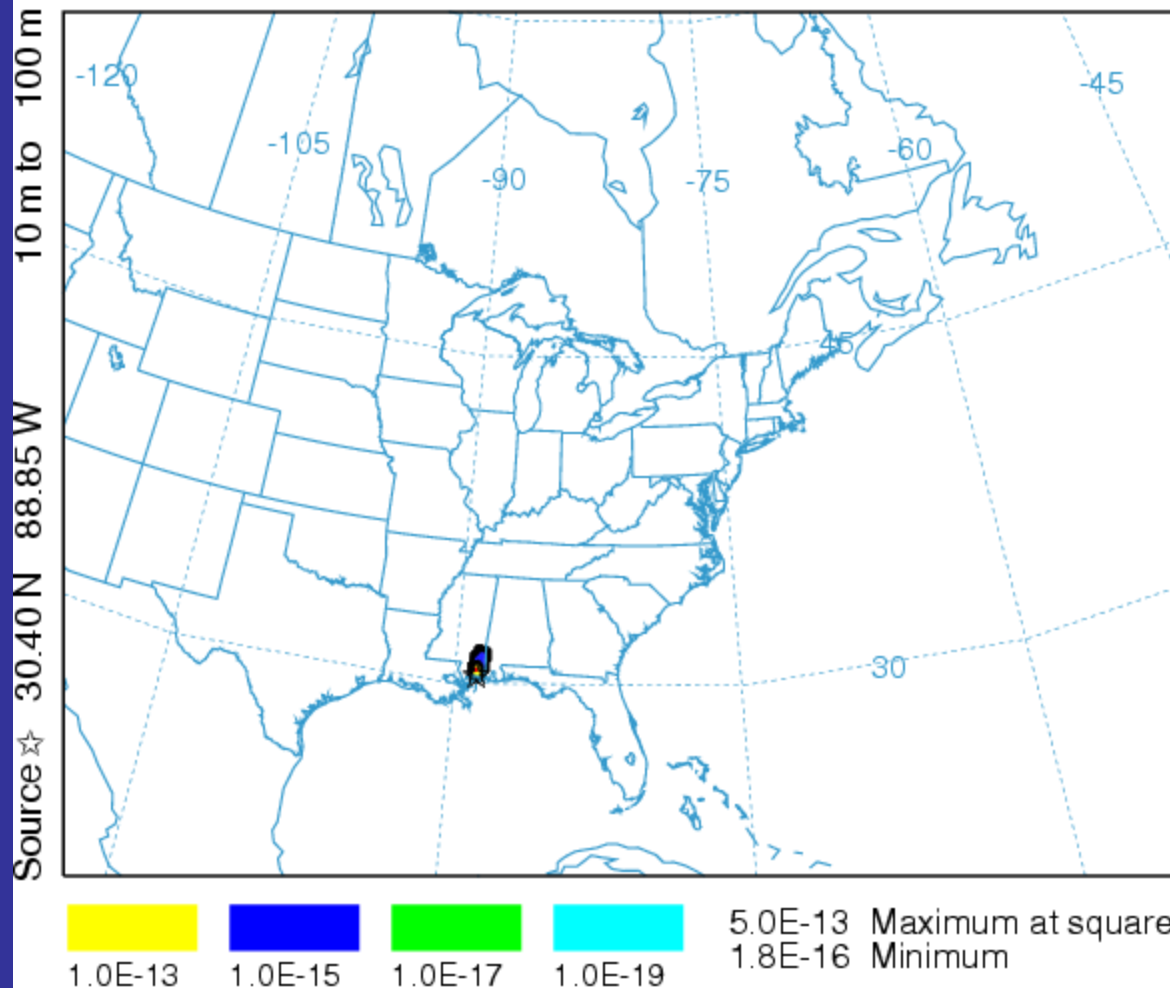
- Air concentrations
- Ground deposition

Hypothetical Gulf
Coast event for May
4, 2003



NOAA HYSPLIT MODEL

Concentration (mass/m³) averaged between 0 m and 6000 m
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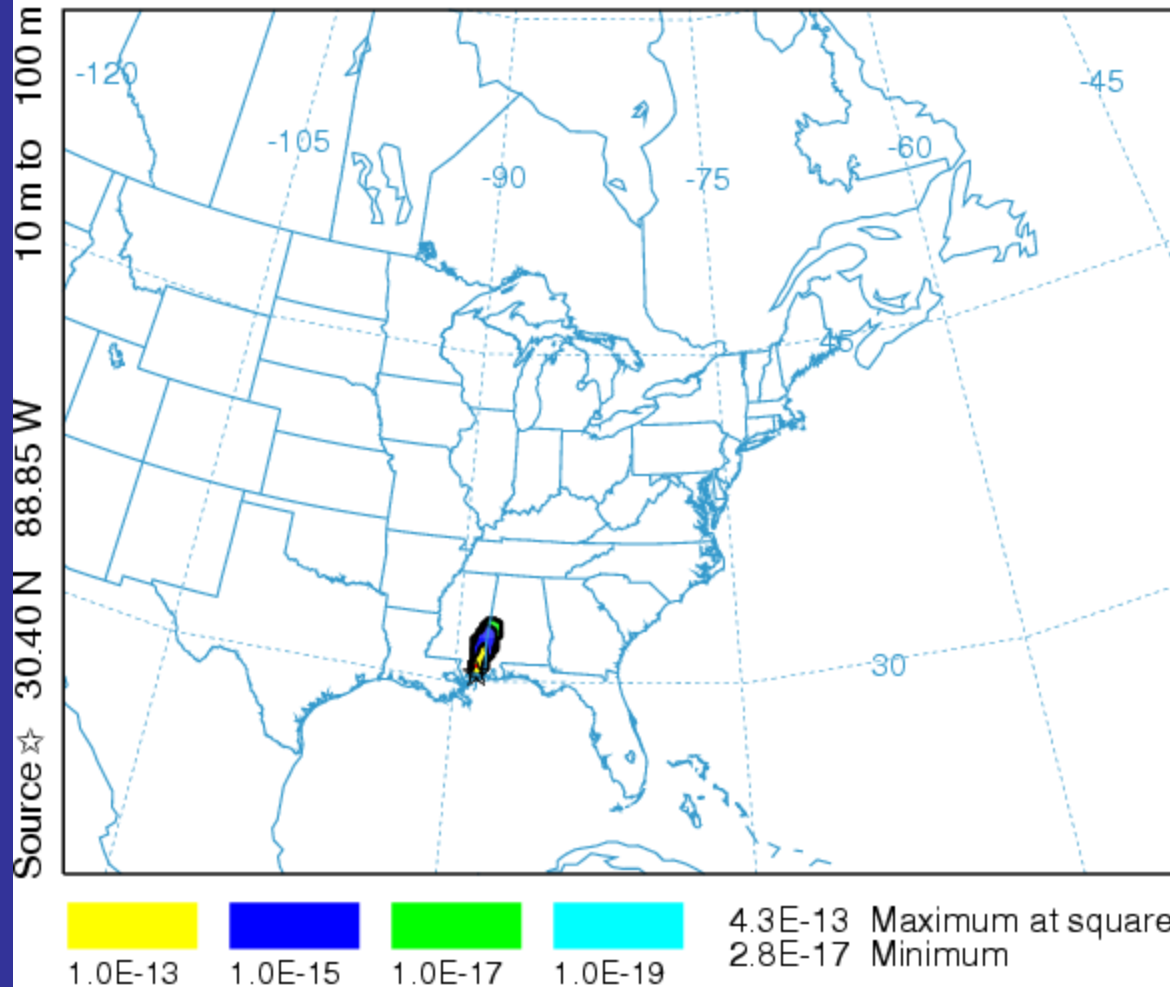


EDAS METEOROLOGICAL DATA

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 Wet Removal (below/in-cloud): 5.0E-05 / 3.2E+05
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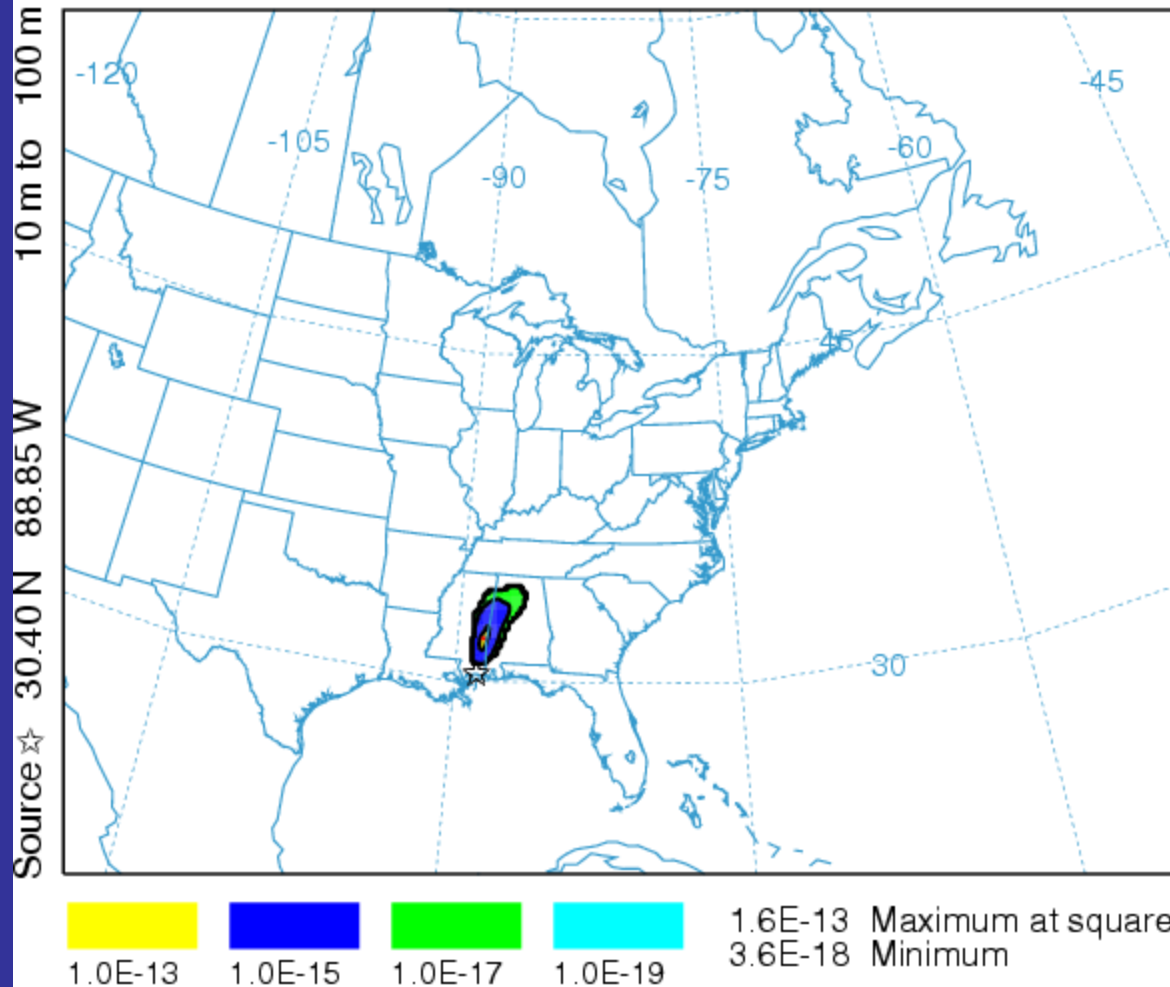


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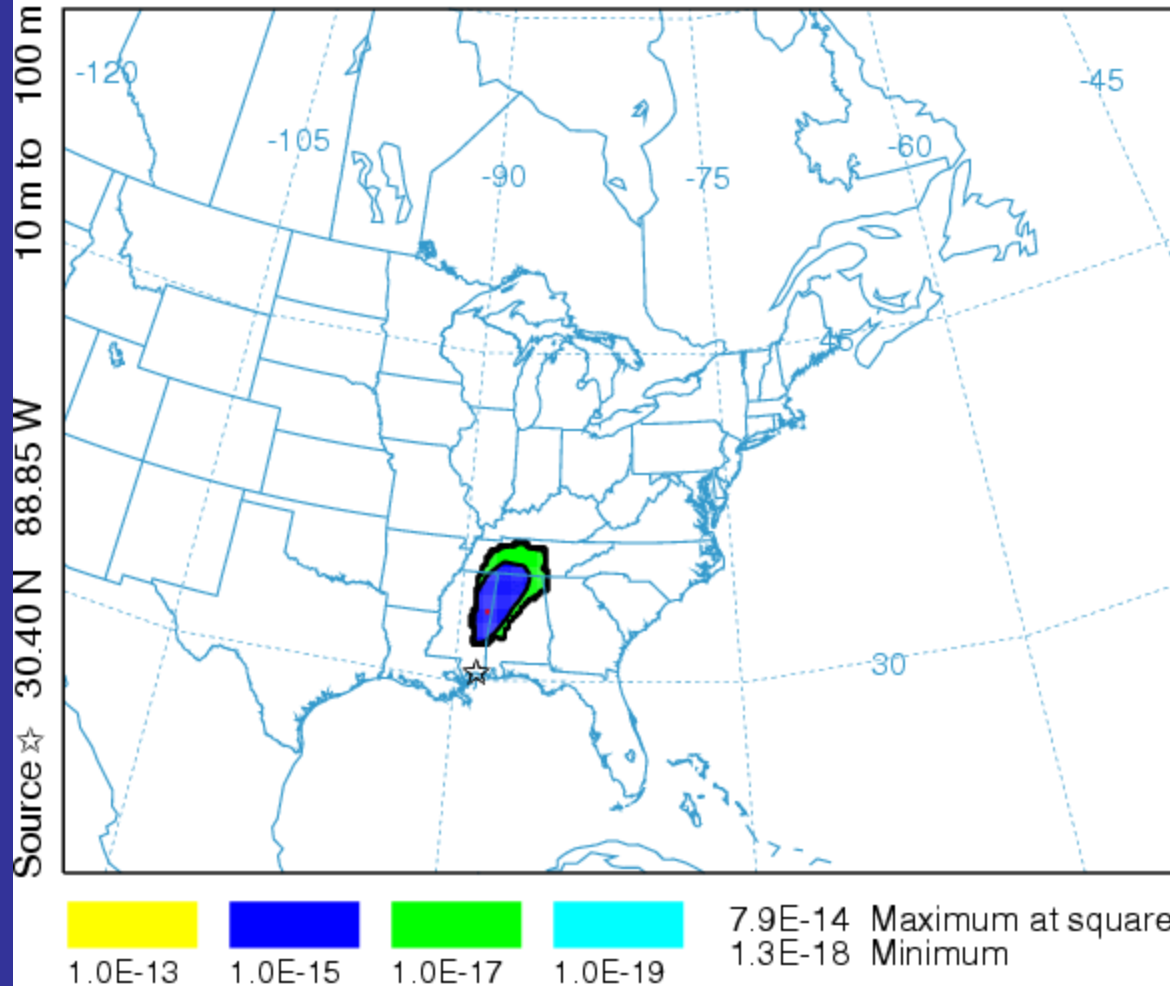


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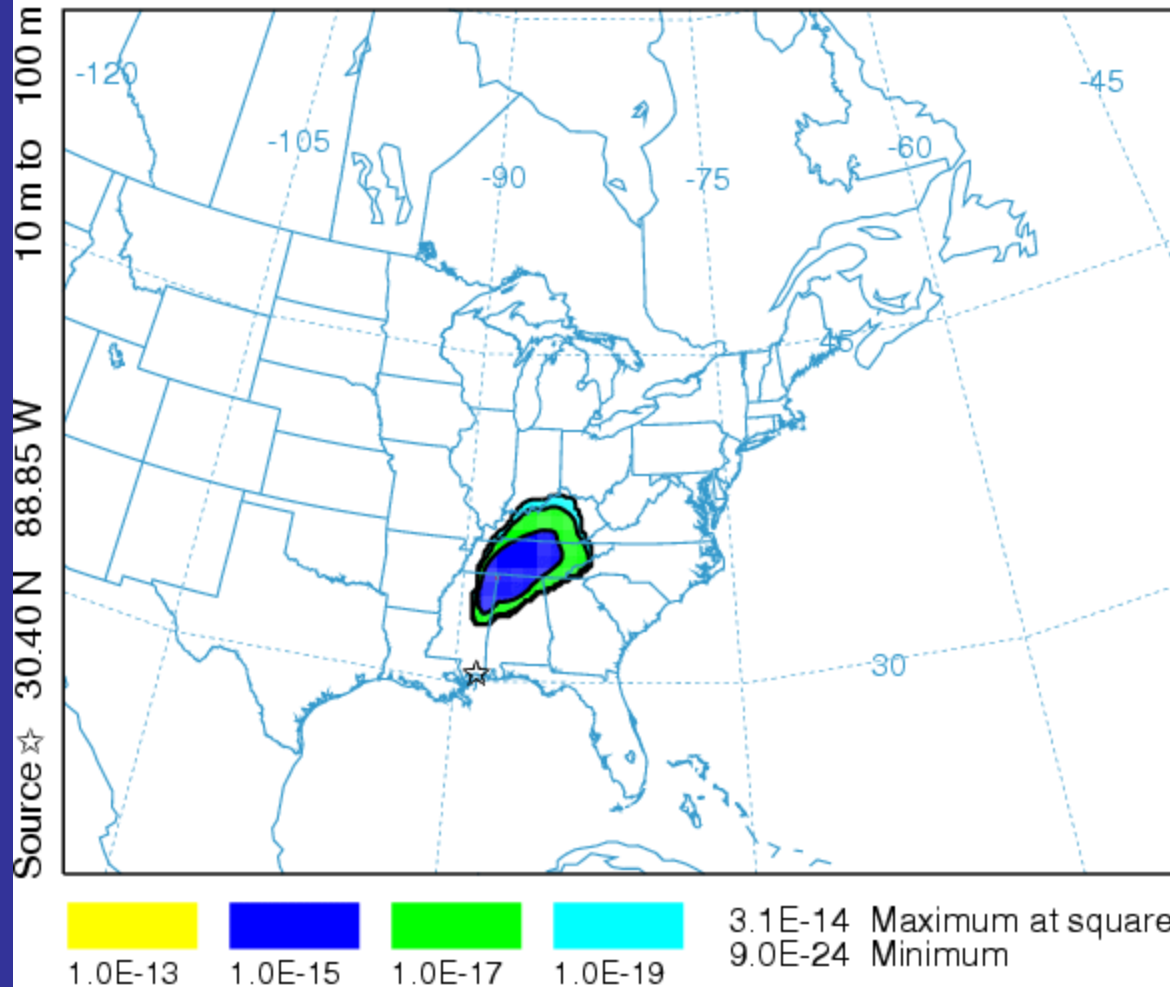


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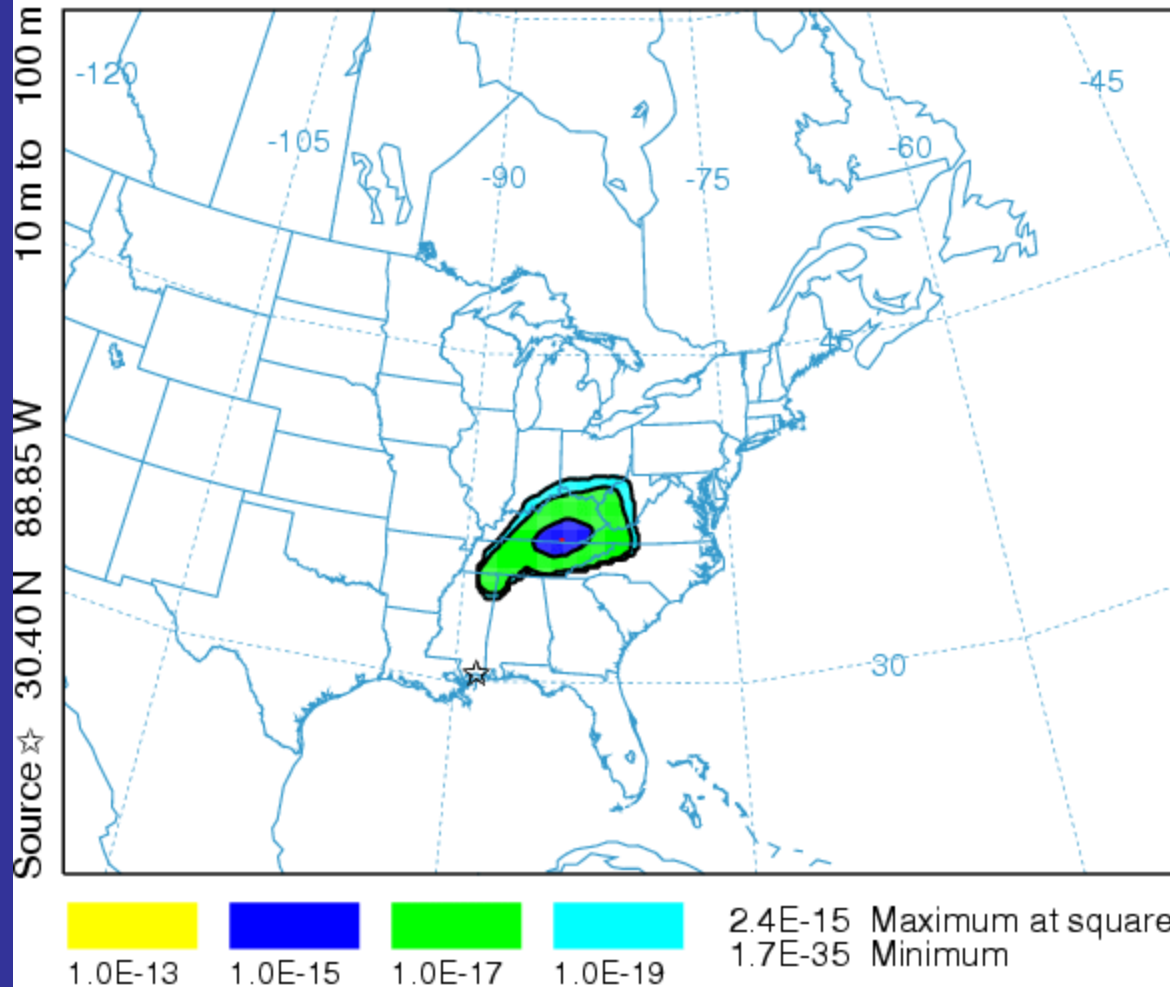


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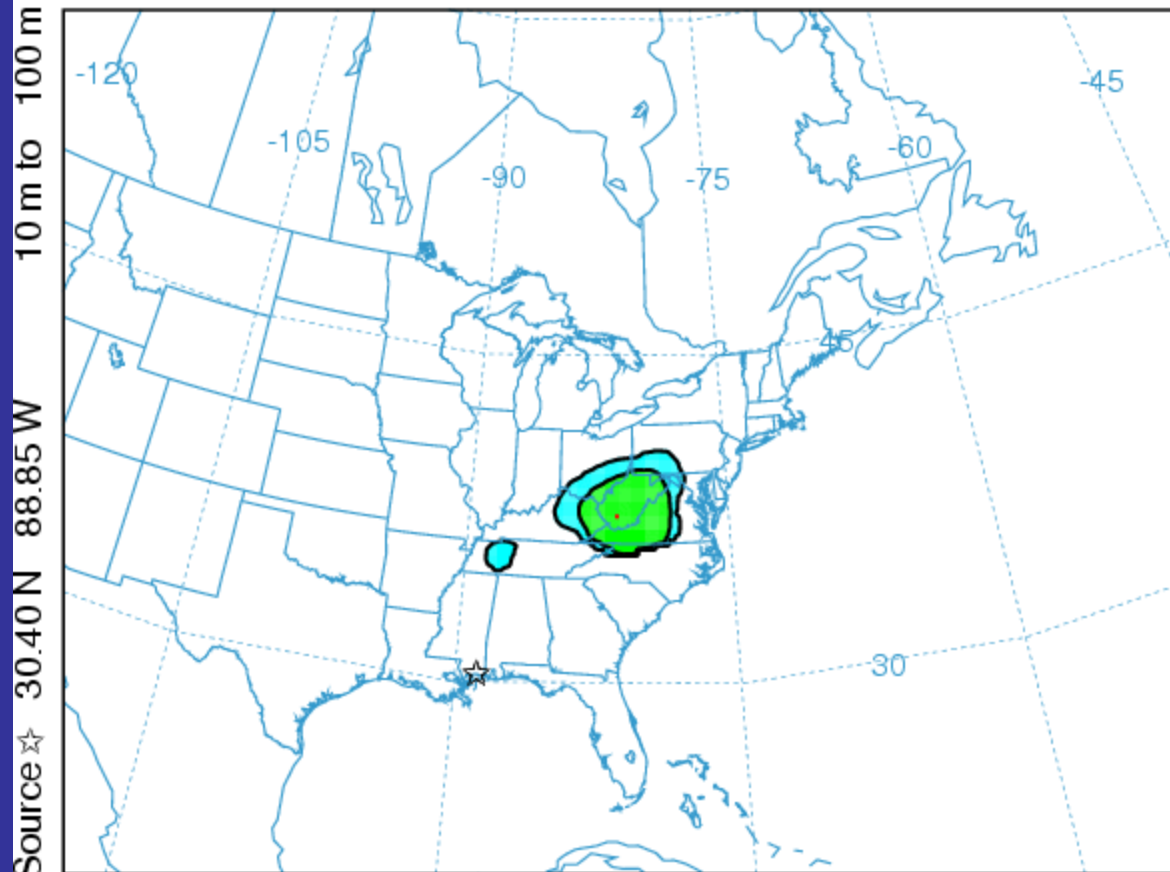


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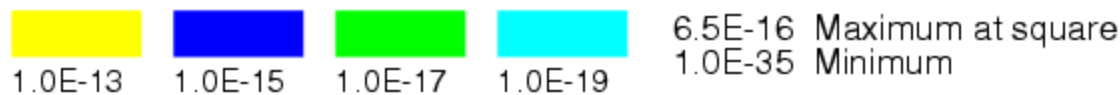
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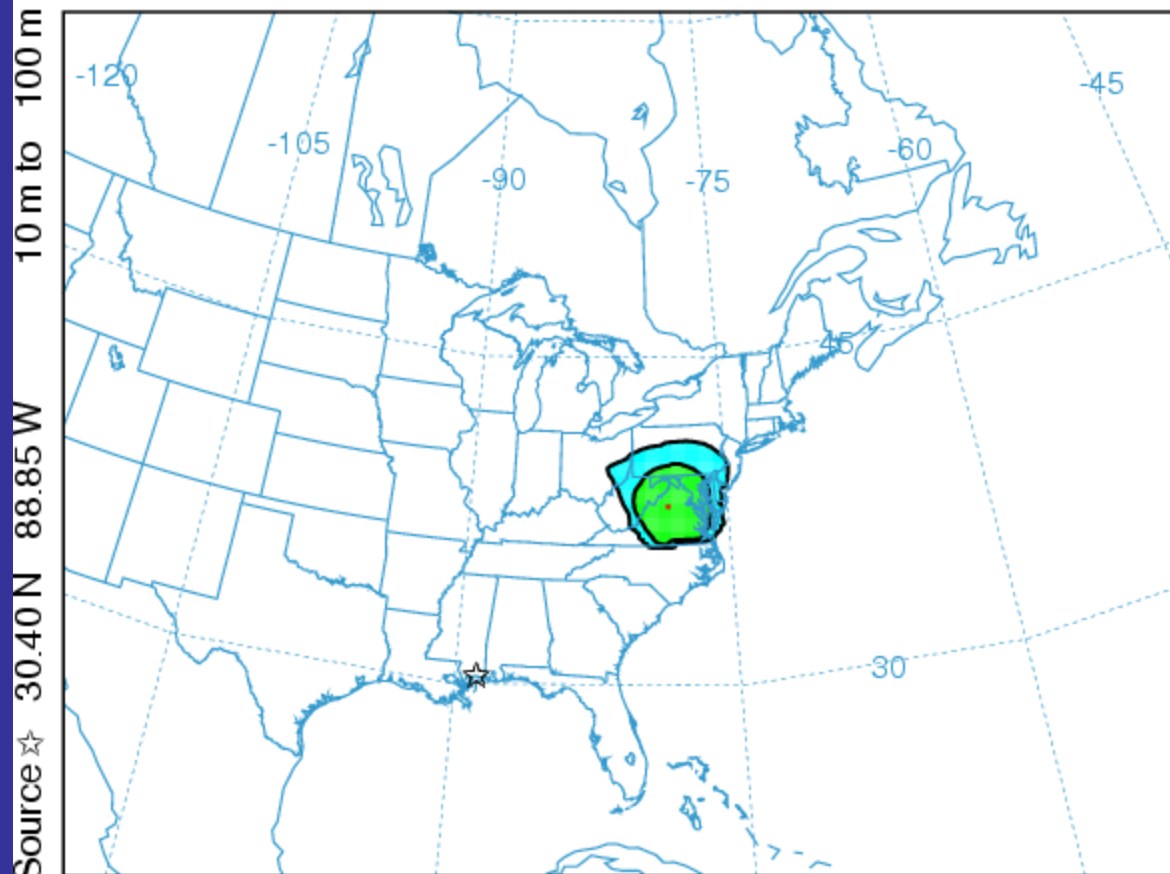
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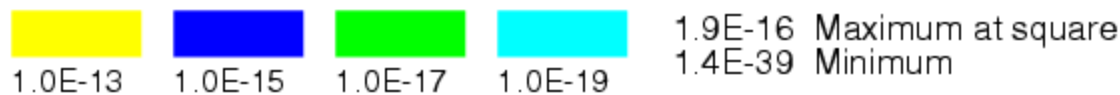
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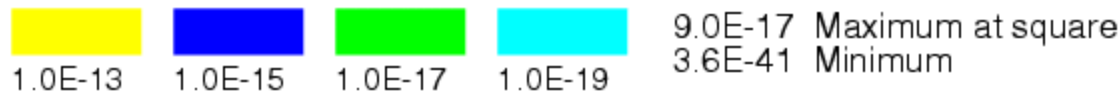
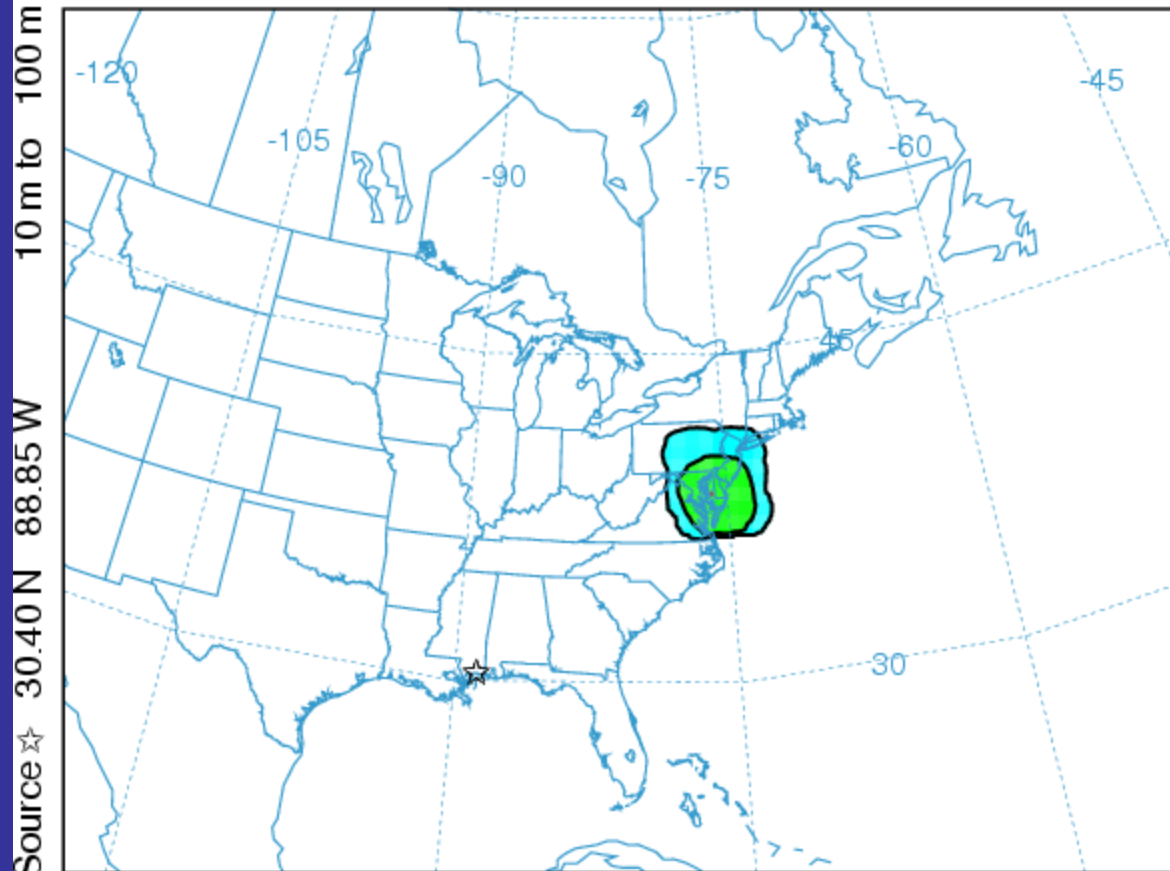
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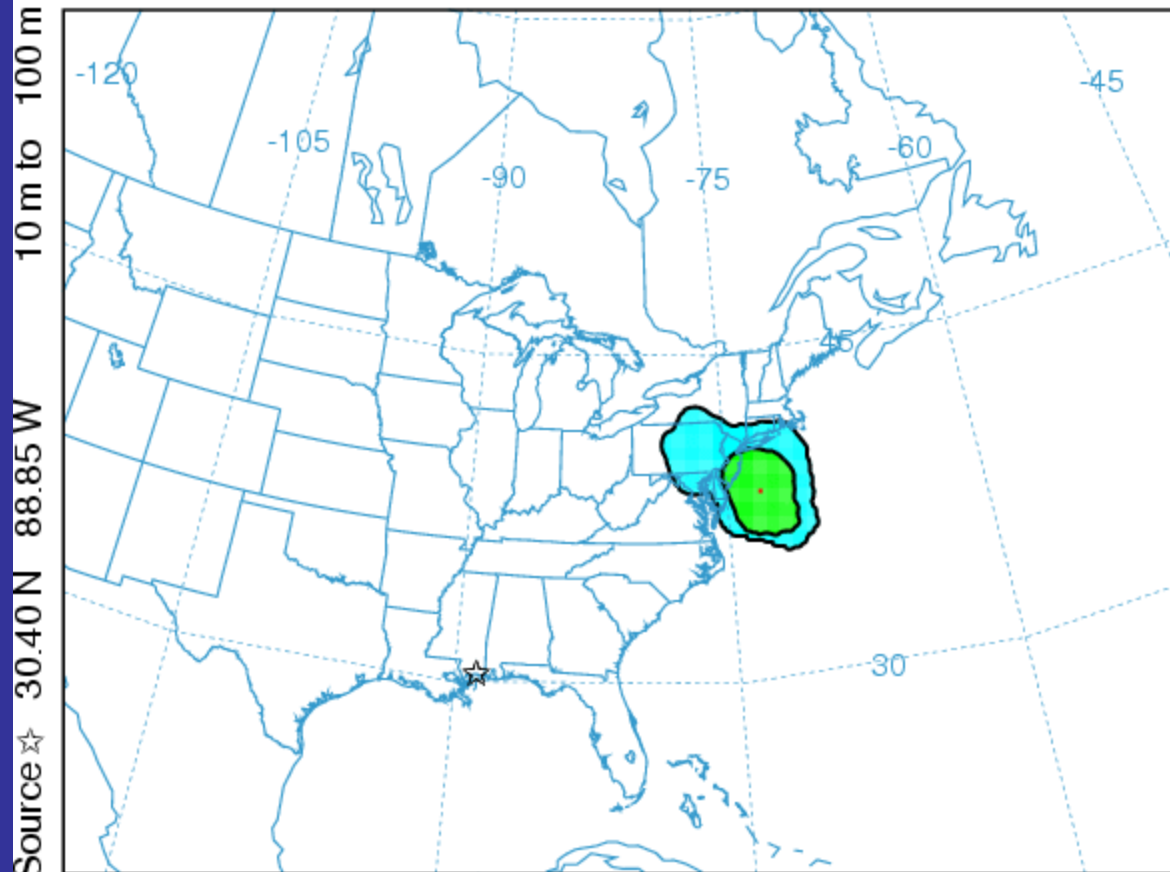
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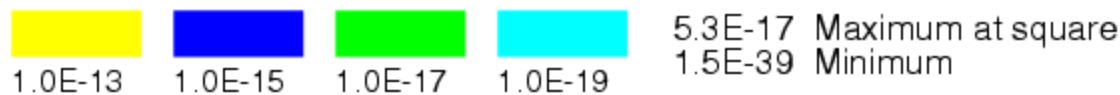
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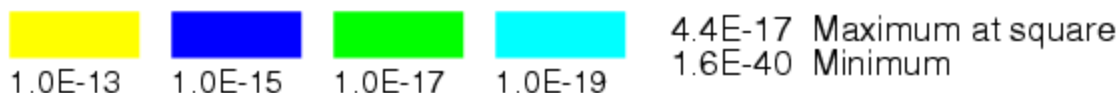
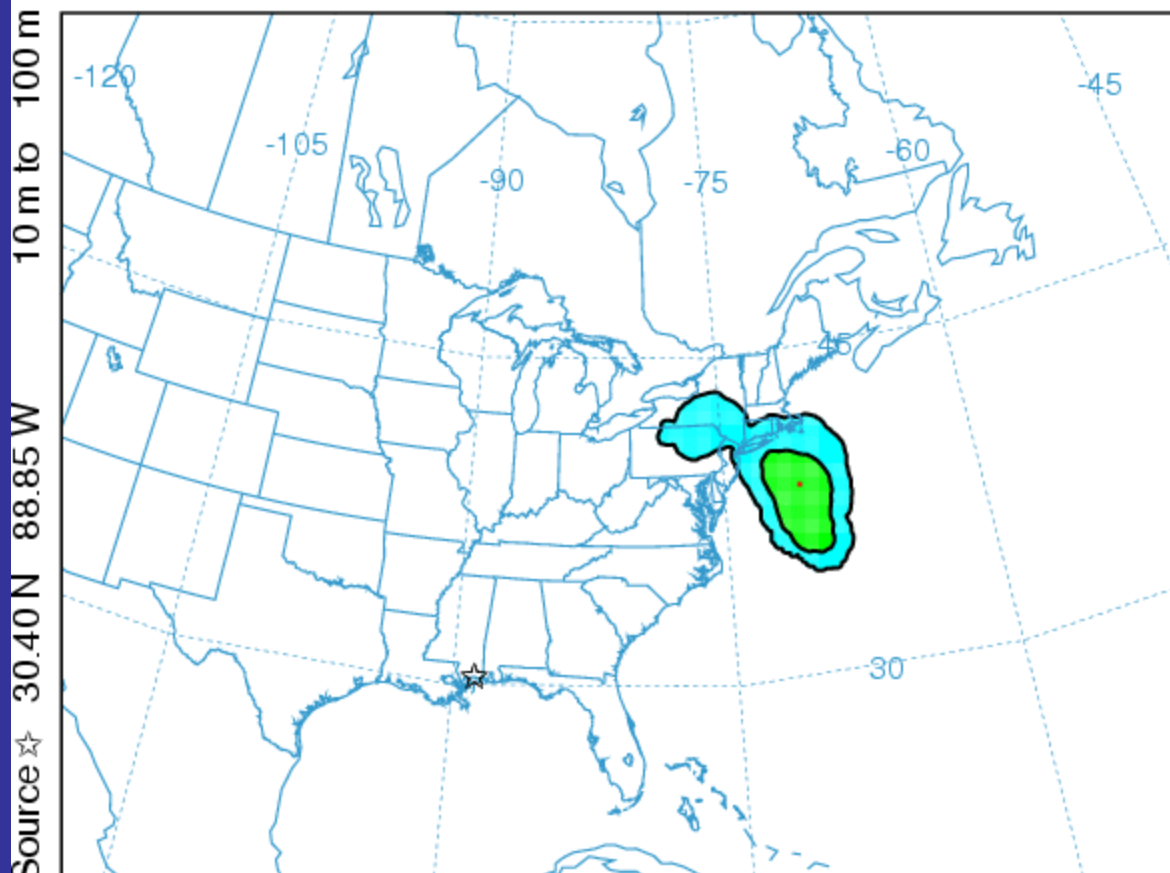
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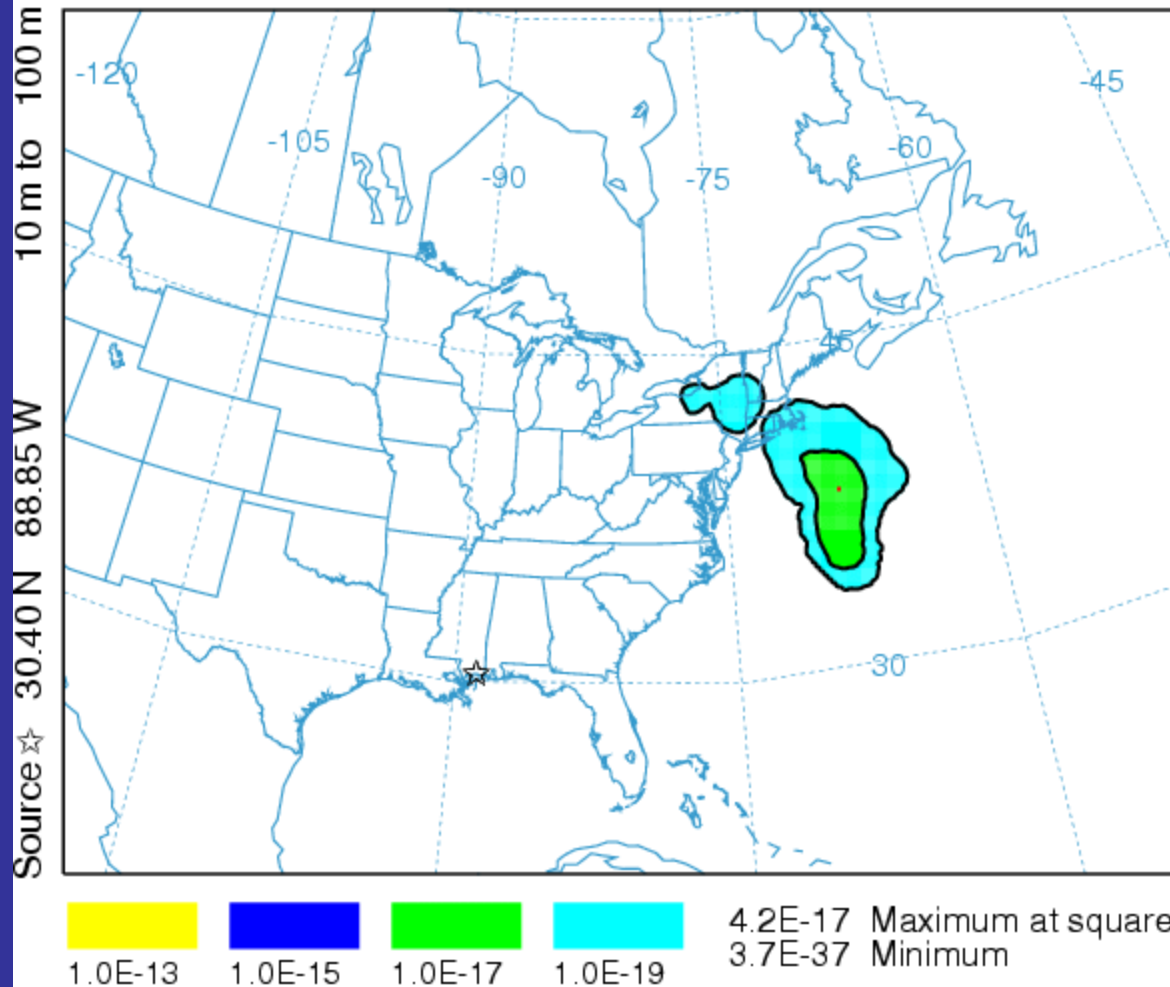
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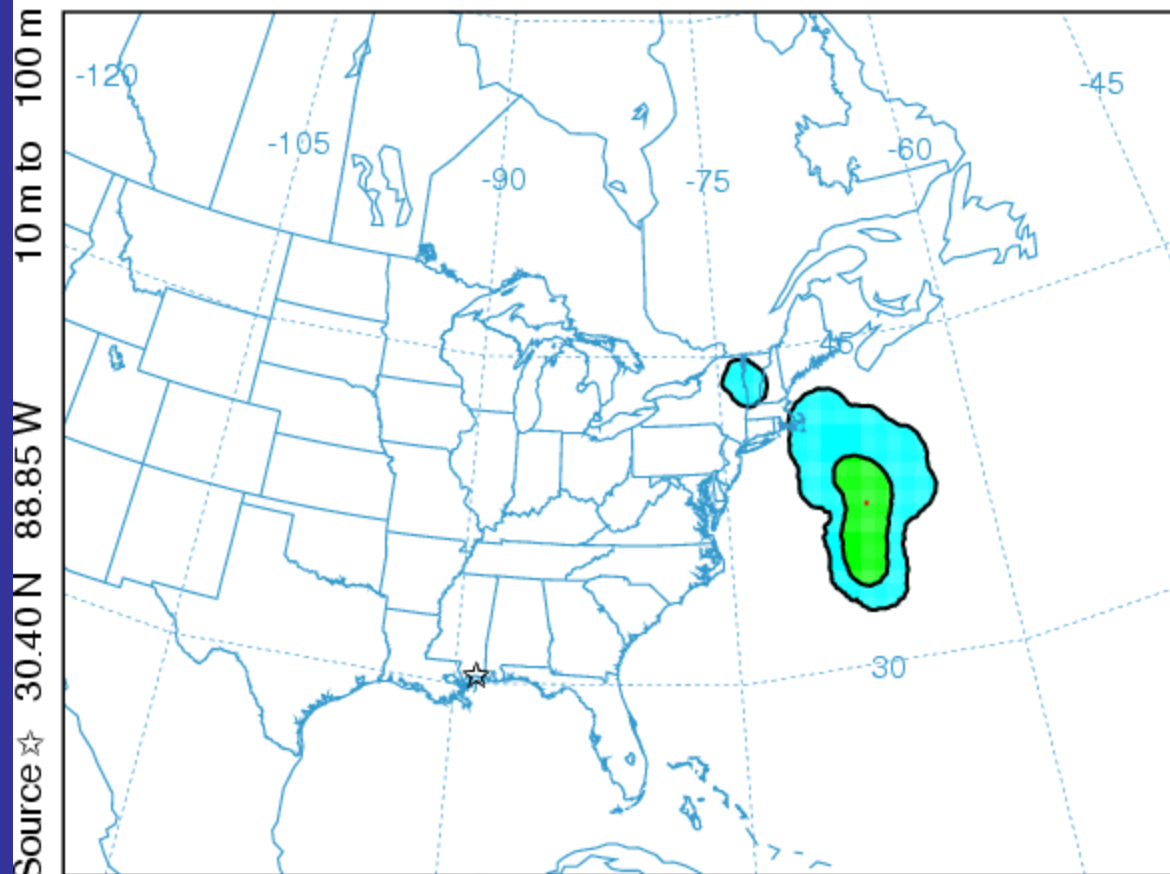


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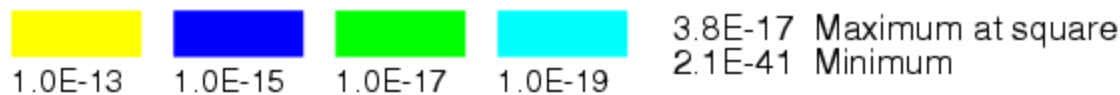
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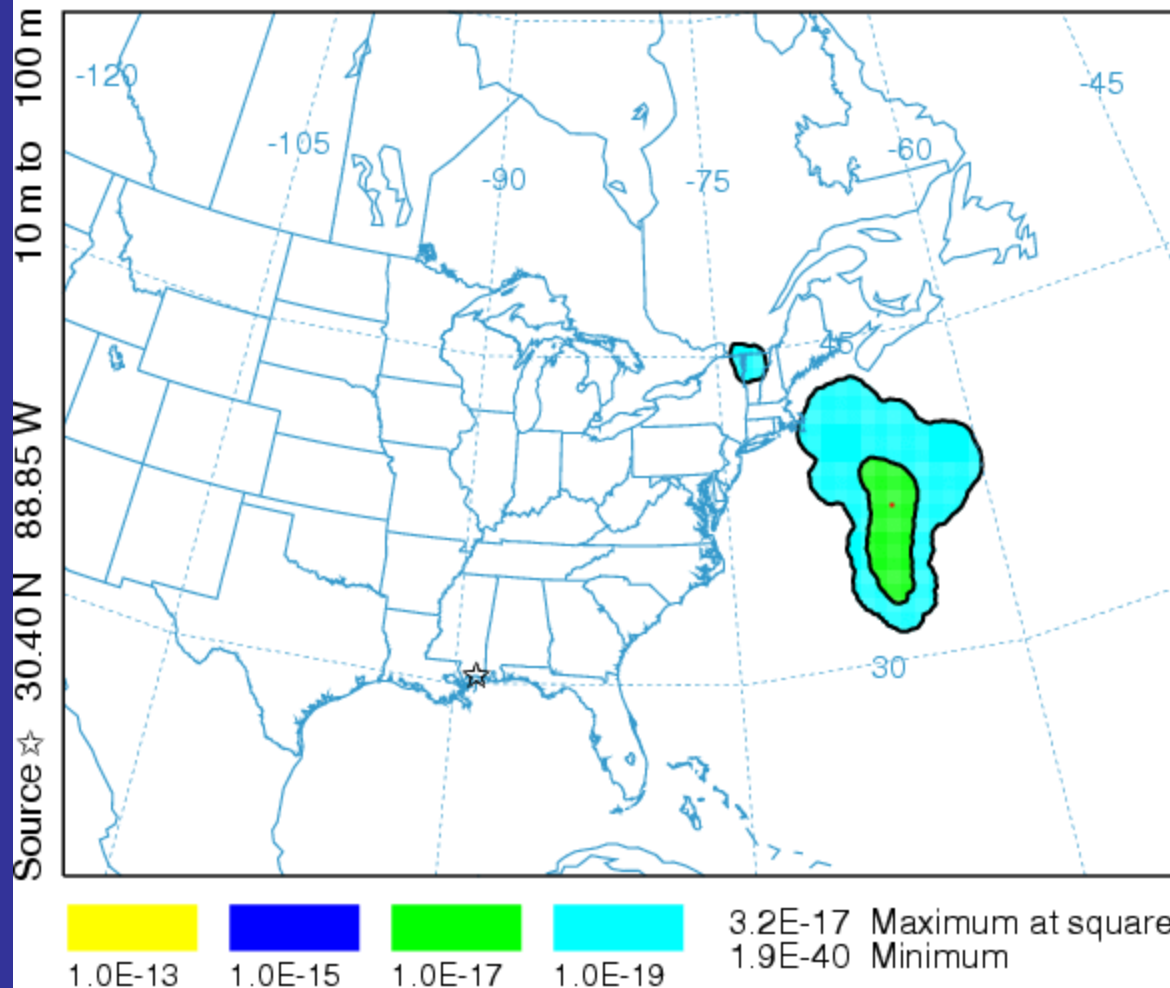
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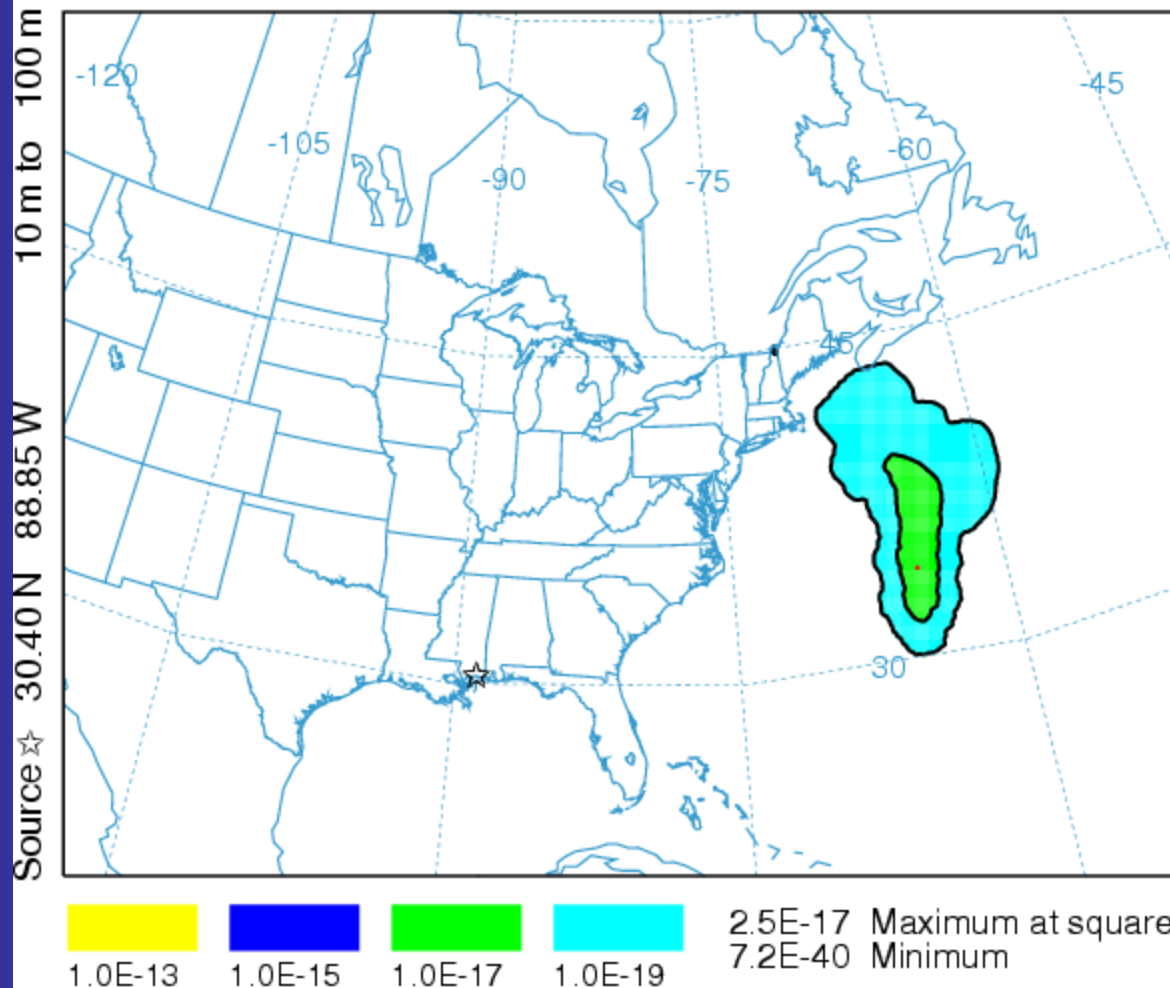


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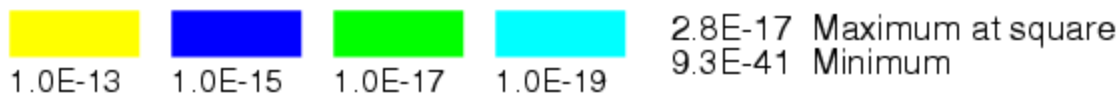
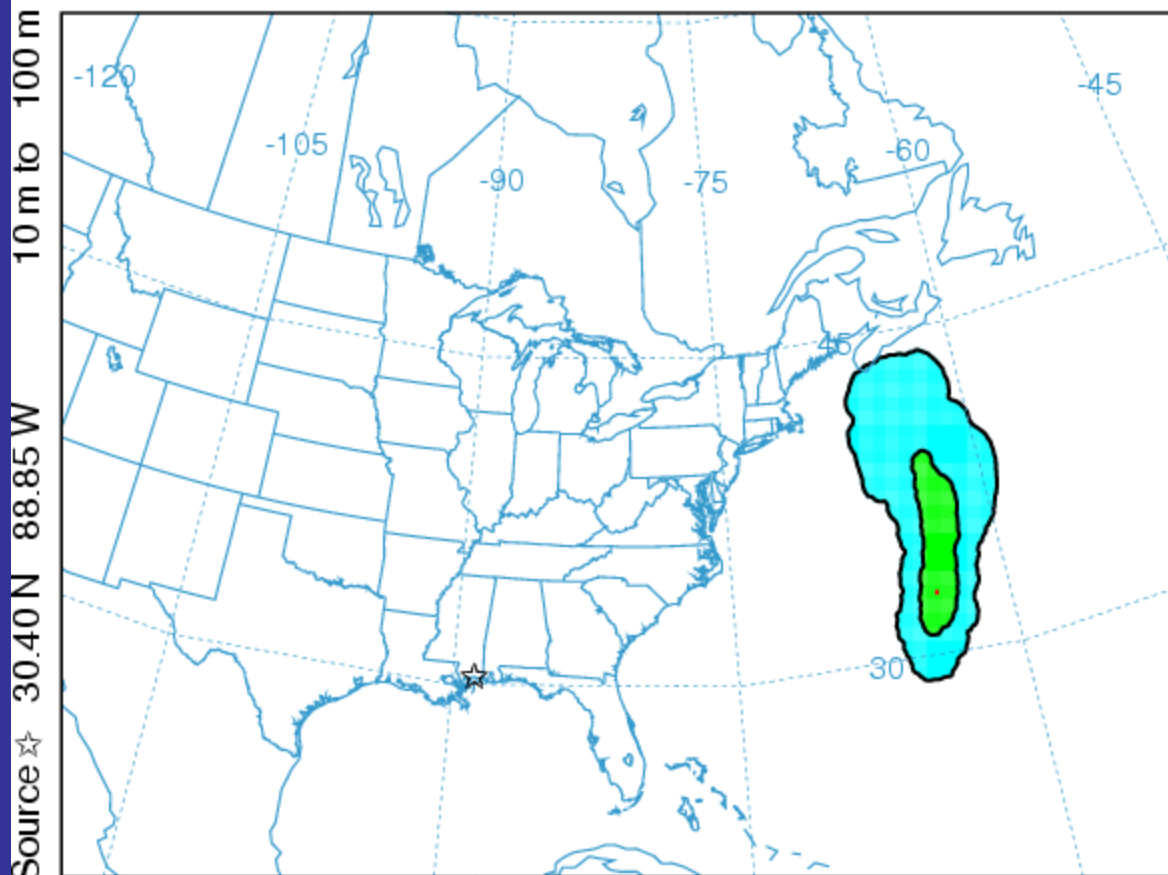


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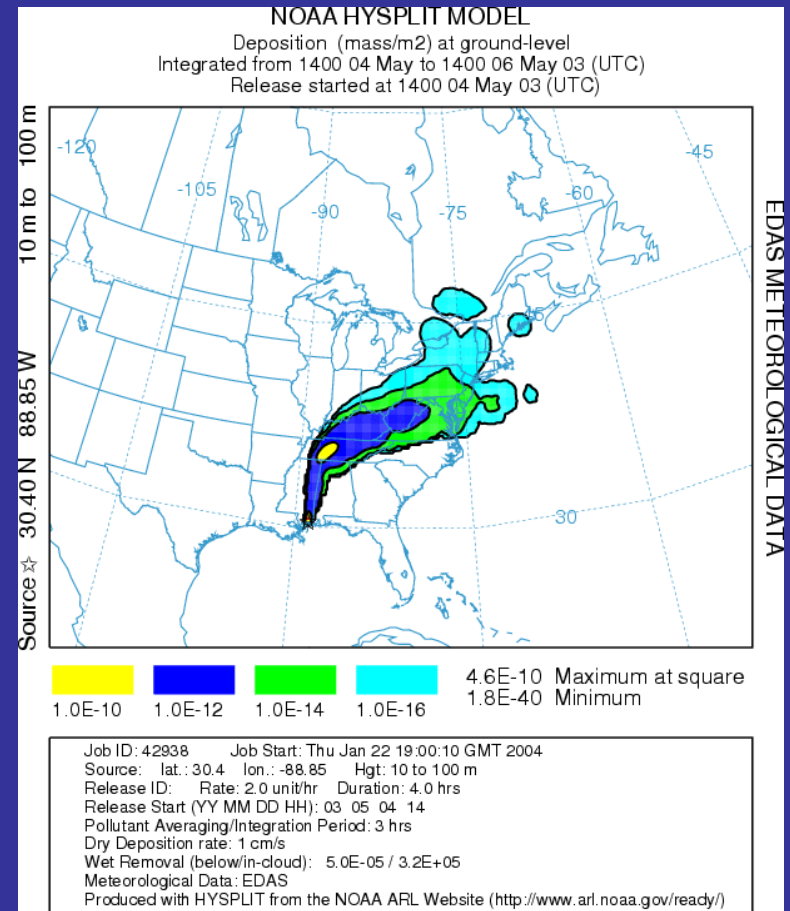
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EDAS METEOROLOGICAL DATA

HYSPLIT IN THE DISPERSION MODE

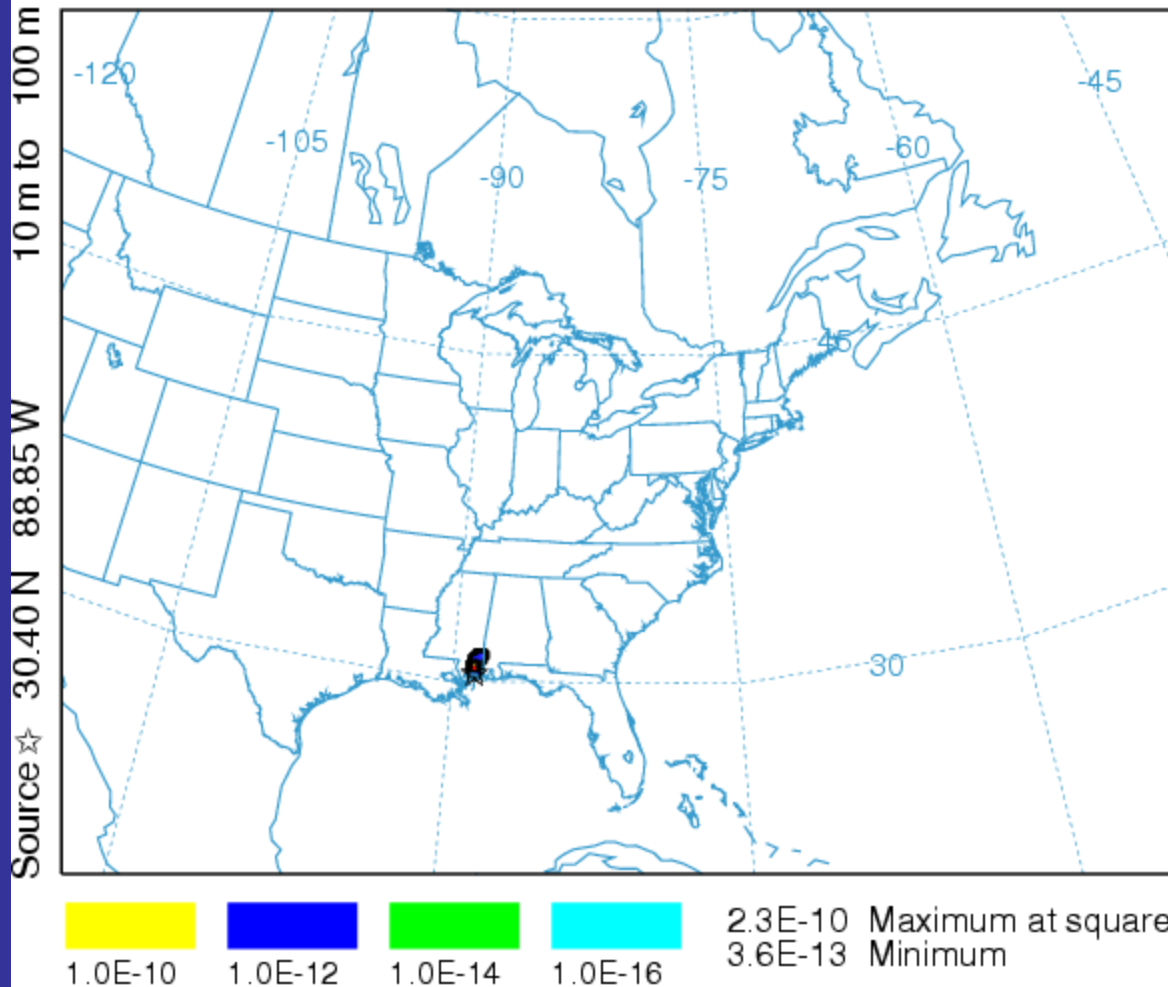
- Air concentrations
- Ground deposition

Hypothetical Gulf Coast event for May 4, 2003



NOAA HYSPLIT MODEL

Deposition (mass/m²) at ground-level
Integrated from 1400 04 May to 1700 04 May 03 (UTC)
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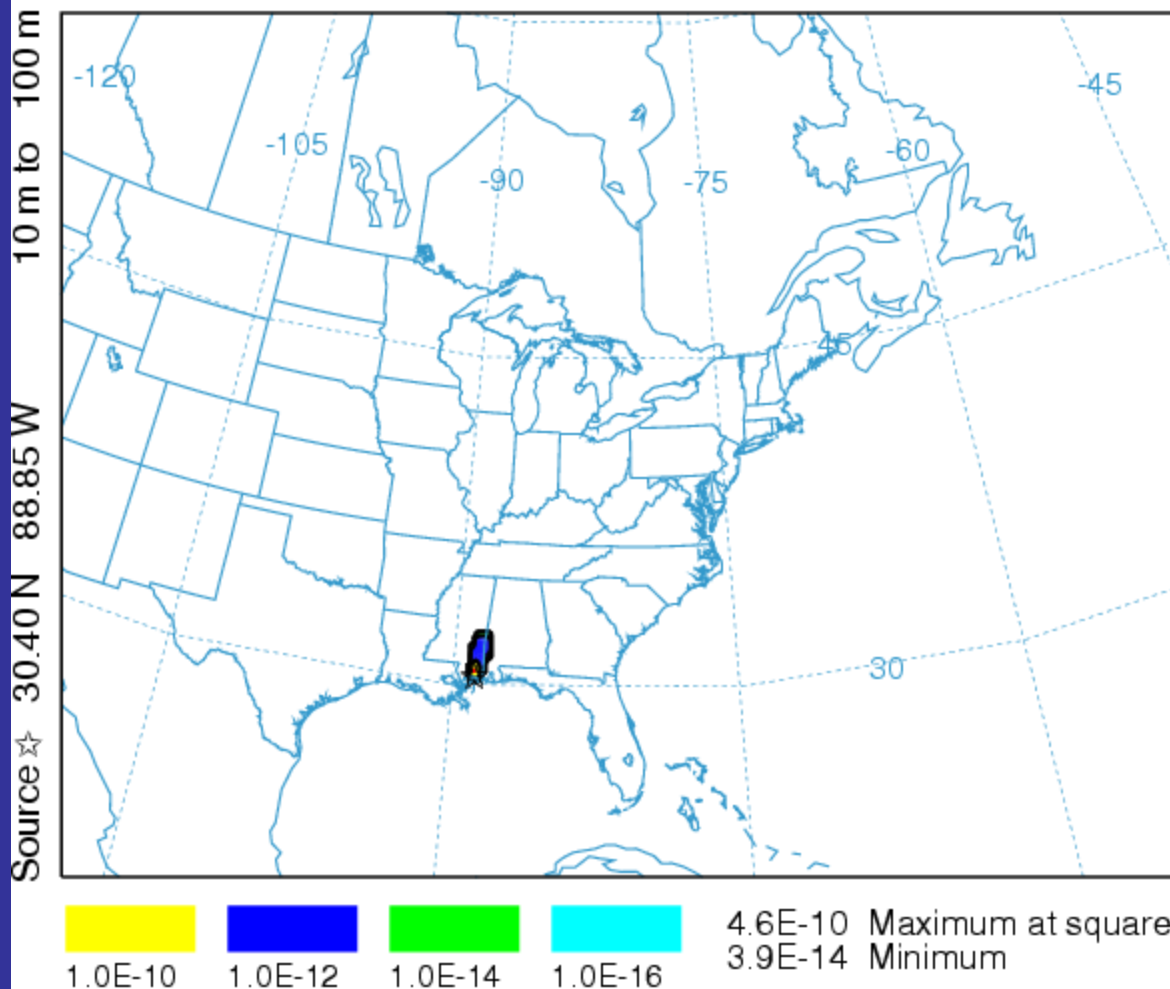


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Integrated from 1400 04 May to 2000 04 May 03 (UTC)
Release started at 1400 04 May 03 (UTC)

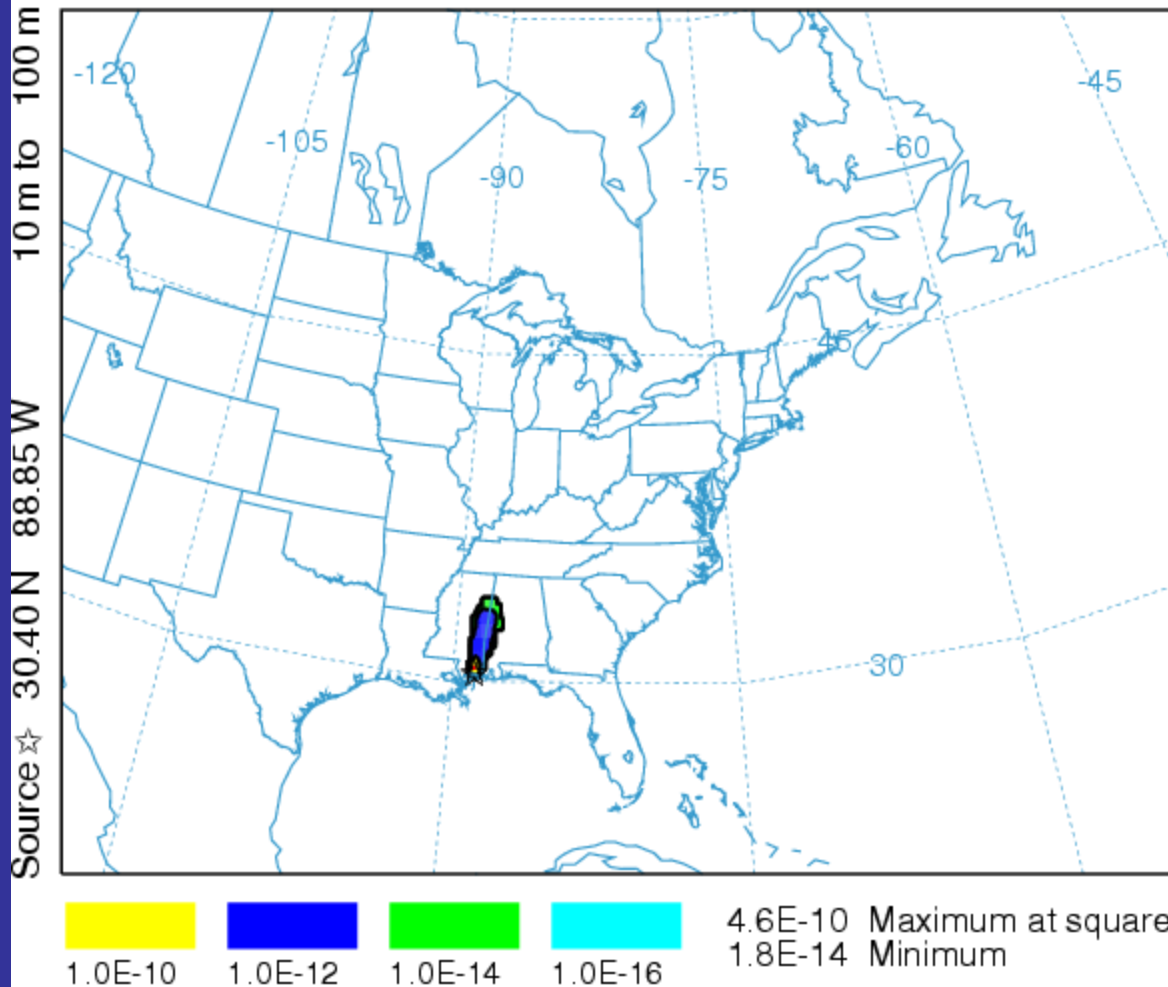


EDAS METEOROLOGICAL DATA

Job ID: 42938 Job Start: Thu Jan 22 19:00:10 GMT 2004
Source: lat.: 30.4 lon.: -88.85 Hgt: 10 to 100 m
Release ID: Rate: 2.0 unit/hr Duration: 4.0 hrs
Release Start (YY MM DD HH): 03 05 04 14
Pollutant Averaging/Integration Period: 3 hrs
Dry Deposition rate: 1 cm/s
Wet Removal (below/in-cloud): 5.0E-05 / 3.2E+05
Meteorological Data: EDAS
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL

Deposition (mass/m²) at ground-level
Integrated from 1400 04 May to 2300 04 May 03 (UTC)
Release started at 1400 04 May 03 (UTC)

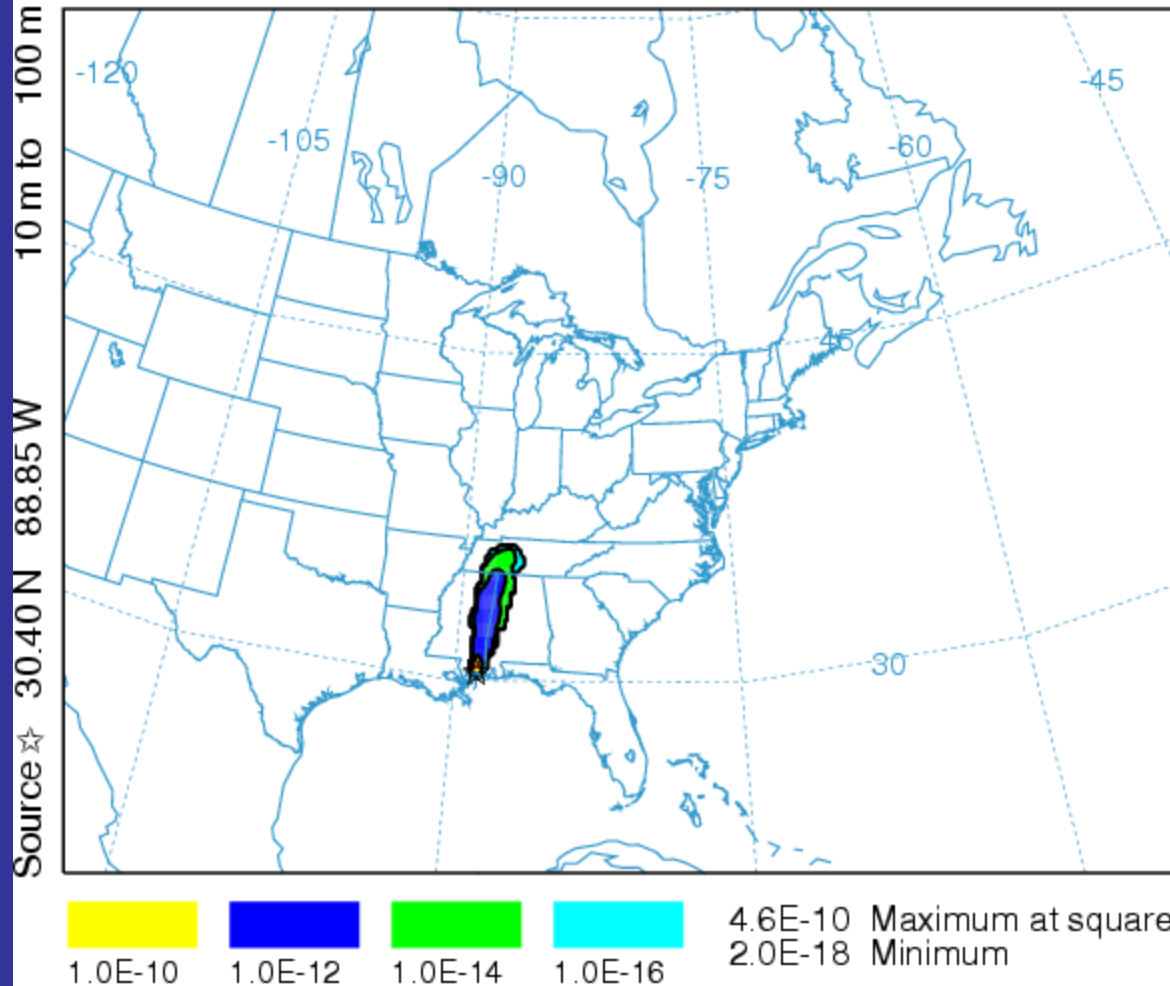


EDAS METEOROLOGICAL DATA

Job ID: 42938 Job Start: Thu Jan 22 19:00:10 GMT 2004
Source: lat.: 30.4 lon.: -88.85 Hgt: 10 to 100 m
Release ID: Rate: 2.0 unit/hr Duration: 4.0 hrs
Release Start (YY MM DD HH): 03 05 04 14
Pollutant Averaging/Integration Period: 3 hrs
Dry Deposition rate: 1 cm/s
Wet Removal (below/in-cloud): 5.0E-05 / 3.2E+05
Meteorological Data: EDAS
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL

Deposition (mass/m²) at ground-level
Integrated from 1400 04 May to 0200 05 May 03 (UTC)
Release started at 1400 04 May 03 (UTC)

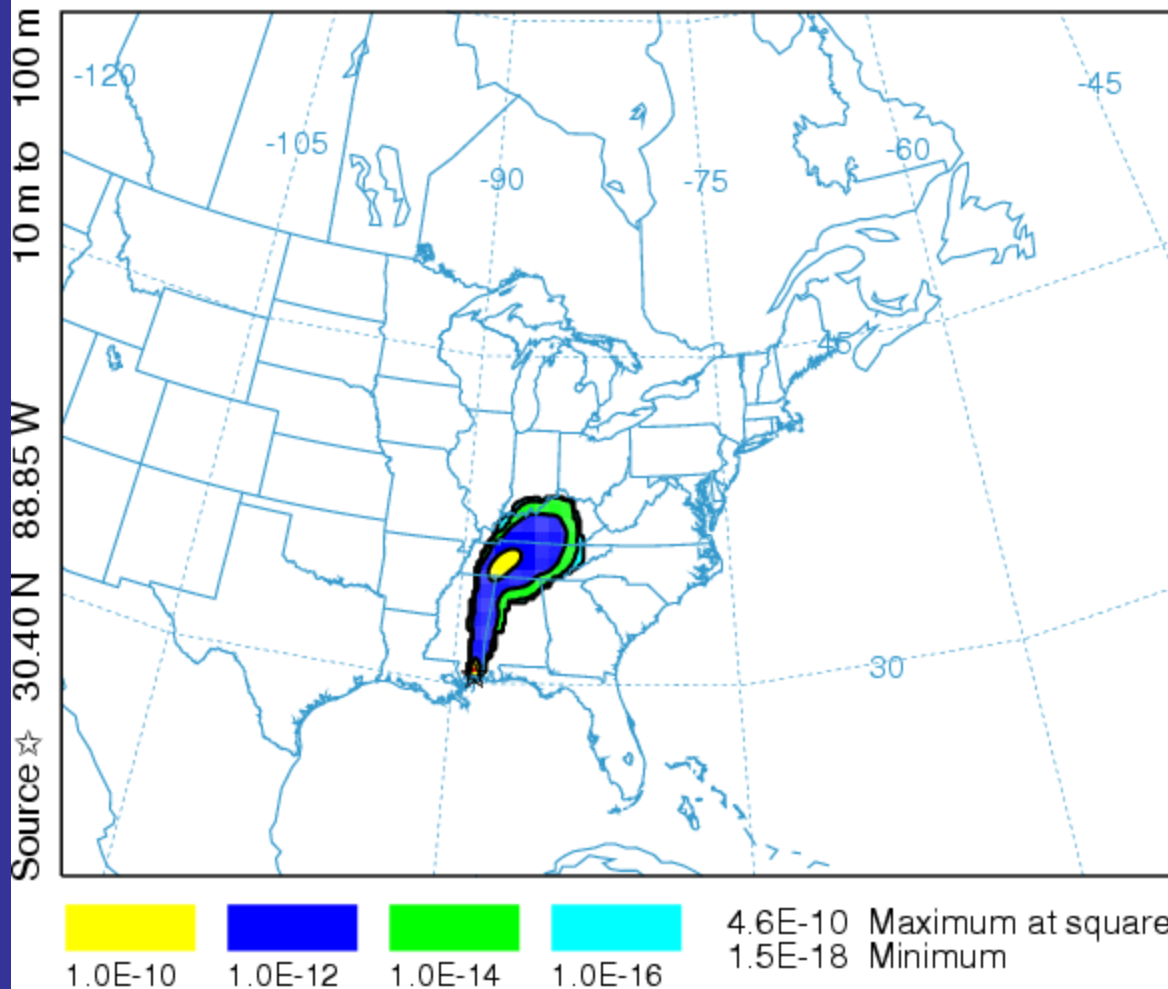


EDAS METEOROLOGICAL DATA

Job ID: 42938 Job Start: Thu Jan 22 19:00:10 GMT 2004
Source: lat.: 30.4 lon.: -88.85 Hgt: 10 to 100 m
Release ID: Rate: 2.0 unit/hr Duration: 4.0 hrs
Release Start (YY MM DD HH): 03 05 04 14
Pollutant Averaging/Integration Period: 3 hrs
Dry Deposition rate: 1 cm/s
Wet Removal (below/in-cloud): 5.0E-05 / 3.2E+05
Meteorological Data: EDAS
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL

Deposition (mass/m2) at ground-level
Integrated from 1400 04 May to 0500 05 May 03 (UTC)
Release started at 1400 04 May 03 (UTC)

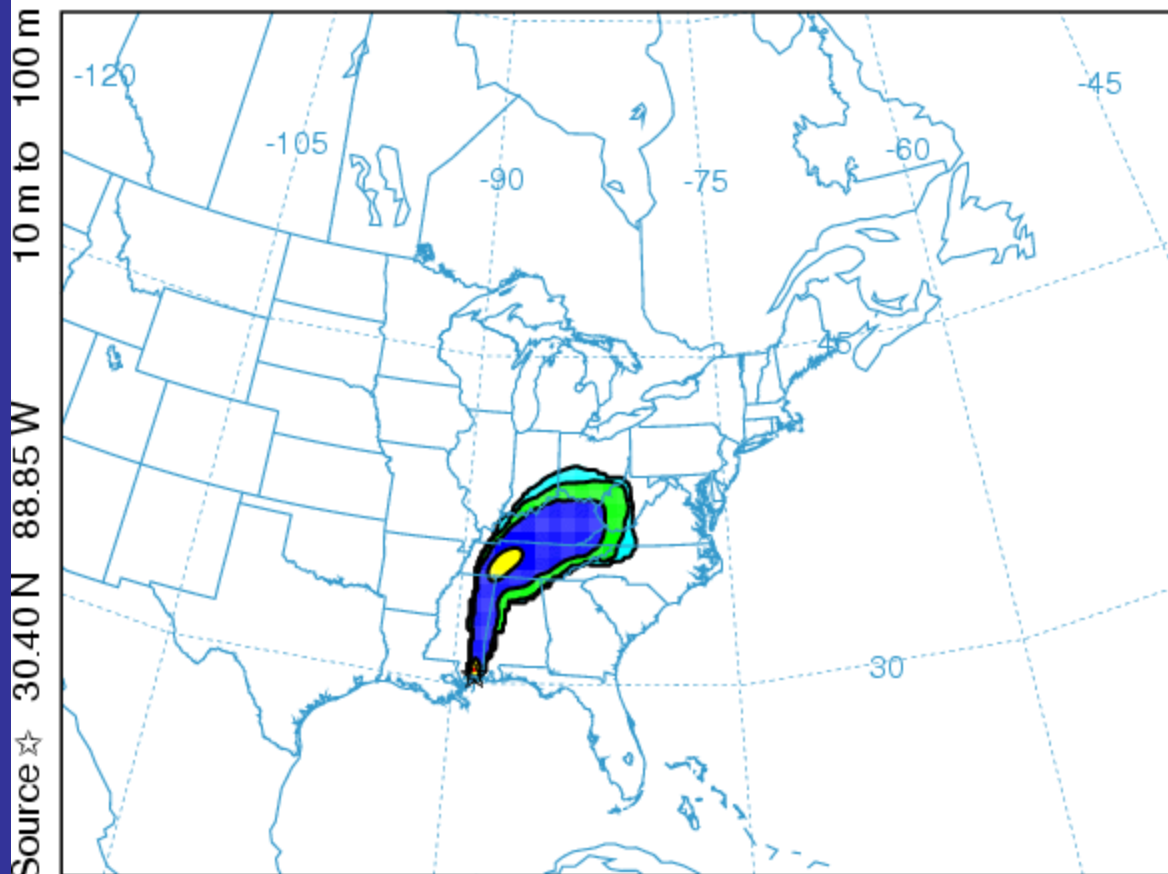


EDAS METEOROLOGICAL DATA

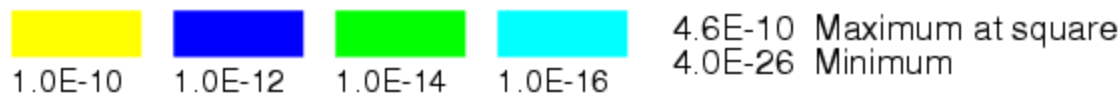
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Source: lat.: 30.4 lon.: -88.85 Hgt: 10 to 100 m
Release ID: Rate: 2.0 unit/hr Duration: 4.0 hrs
Release Start (YY MM DD HH): 03 05 04 14
Pollutant Averaging/Integration Period: 3 hrs
Dry Deposition rate: 1 cm/s
Wet Removal (below/in-cloud): 5.0E-05 / 3.2E+05
Meteorological Data: EDAS
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL

Deposition (mass/m²) at ground-level
Integrated from 1400 04 May to 0800 05 May 03 (UTC)
Release started at 1400 04 May 03 (UTC)



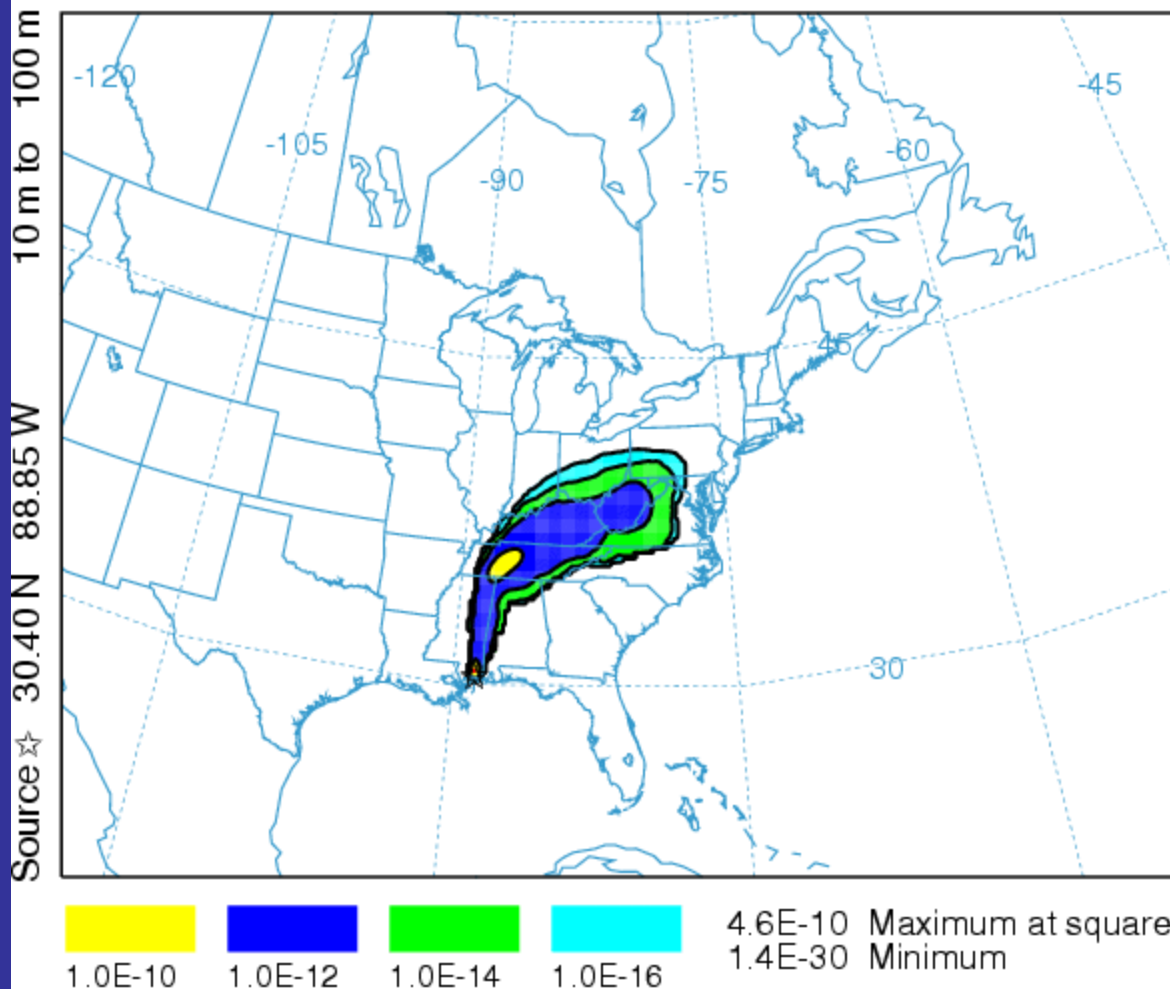
EDAS METEOROLOGICAL DATA



Job ID: 42938 Job Start: Thu Jan 22 19:00:10 GMT 2004
Source: lat.: 30.4 lon.: -88.85 Hgt: 10 to 100 m
Release ID: Rate: 2.0 unit/hr Duration: 4.0 hrs
Release Start (YY MM DD HH): 03 05 04 14
Pollutant Averaging/Integration Period: 3 hrs
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Meteorological Data: EDAS
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL

Deposition (mass/m²) at ground-level
Integrated from 1400 04 May to 1100 05 May 03 (UTC)
Release started at 1400 04 May 03 (UTC)

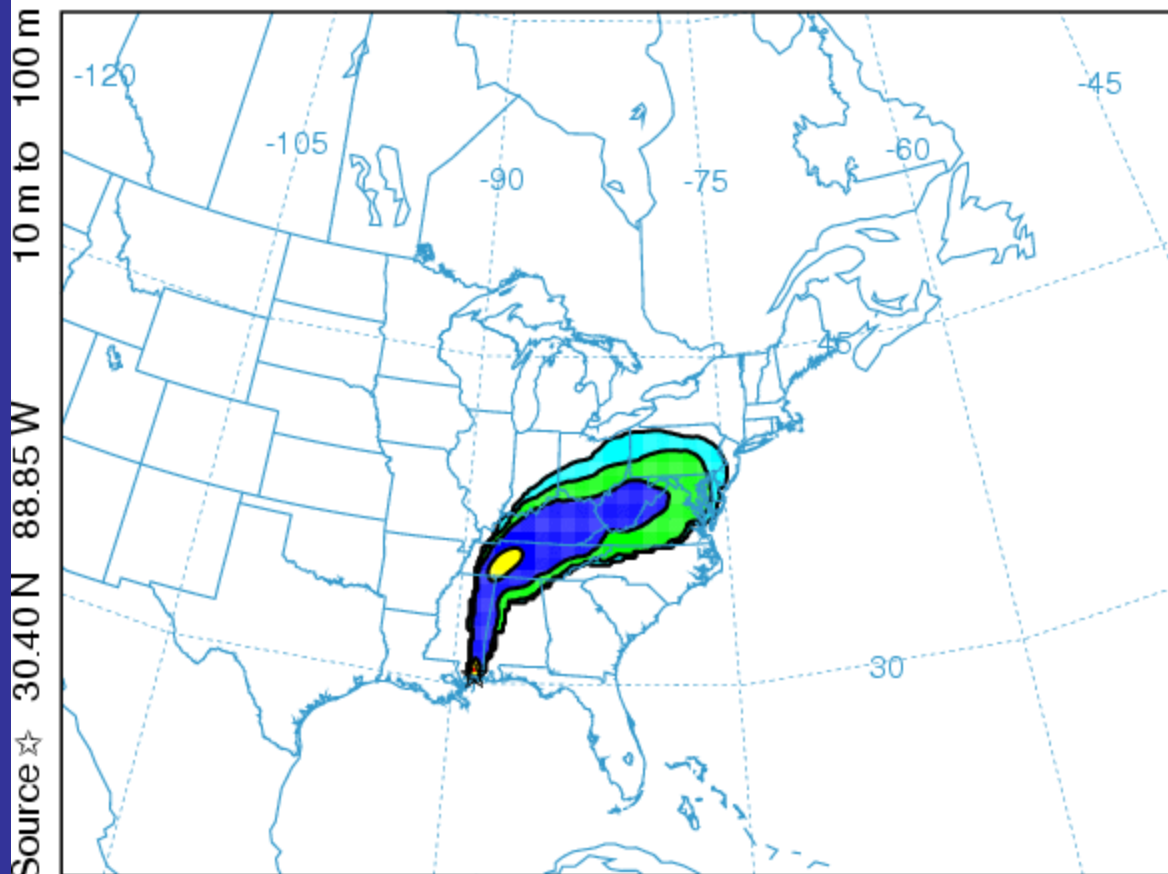


EDAS METEOROLOGICAL DATA

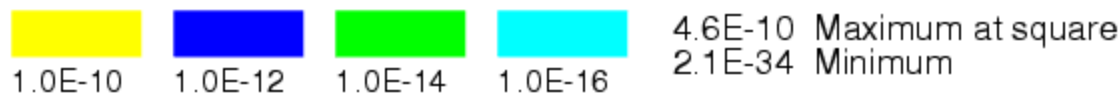
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Release ID: Rate: 2.0 unit/hr Duration: 4.0 hrs
Release Start (YY MM DD HH): 03 05 04 14
Pollutant Averaging/Integration Period: 3 hrs
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Wet Removal (below/in-cloud): 5.0E-05 / 3.2E+05
Meteorological Data: EDAS
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL

Deposition (mass/m²) at ground-level
Integrated from 1400 04 May to 1400 05 May 03 (UTC)
Release started at 1400 04 May 03 (UTC)



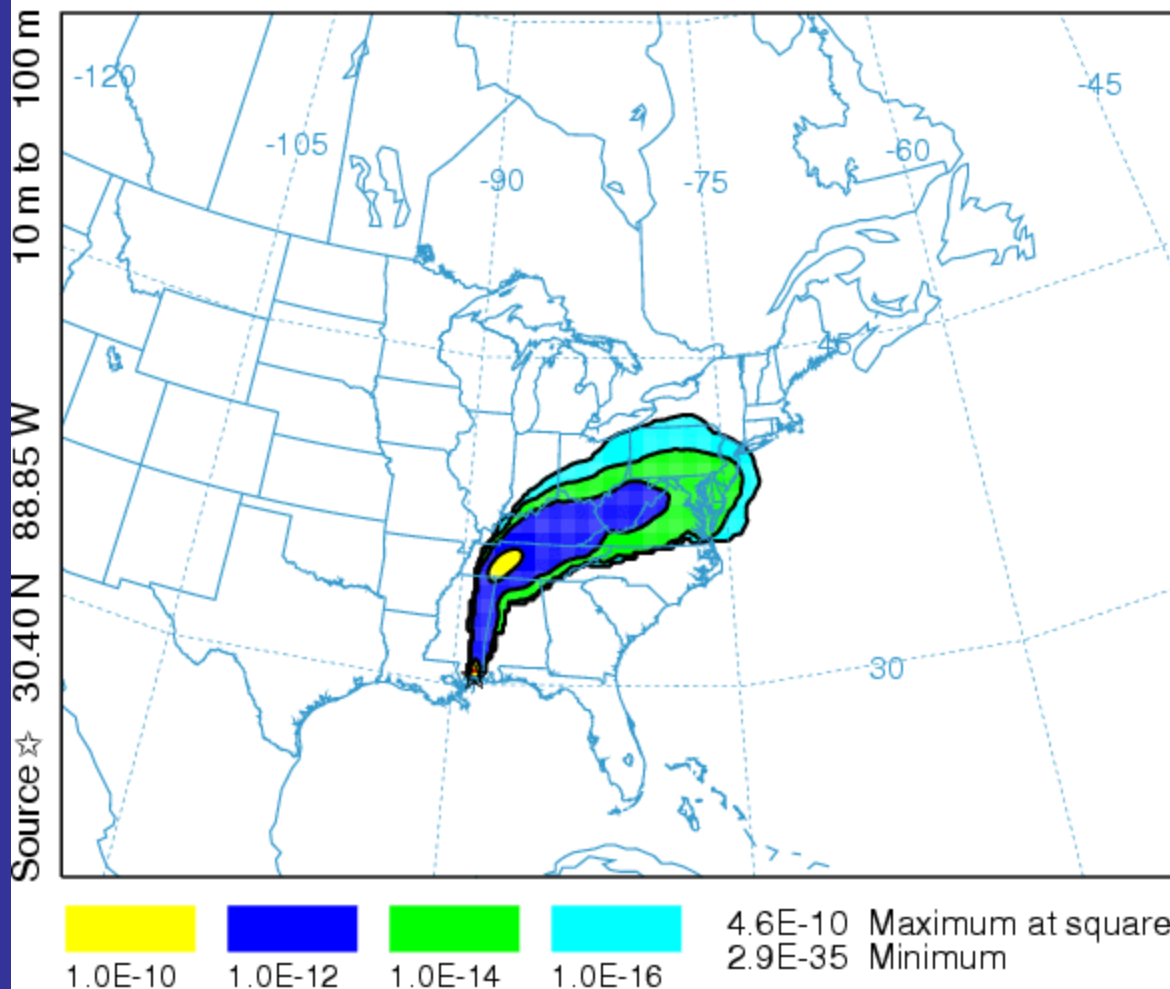
EDAS METEOROLOGICAL DATA



Job ID: 42938 Job Start: Thu Jan 22 19:00:10 GMT 2004
Source: lat.: 30.4 lon.: -88.85 Hgt: 10 to 100 m
Release ID: Rate: 2.0 unit/hr Duration: 4.0 hrs
Release Start (YY MM DD HH): 03 05 04 14
Pollutant Averaging/Integration Period: 3 hrs
Dry Deposition rate: 1 cm/s
Wet Removal (below/in-cloud): 5.0E-05 / 3.2E+05
Meteorological Data: EDAS
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL

Deposition (mass/m²) at ground-level
Integrated from 1400 04 May to 1700 05 May 03 (UTC)
Release started at 1400 04 May 03 (UTC)

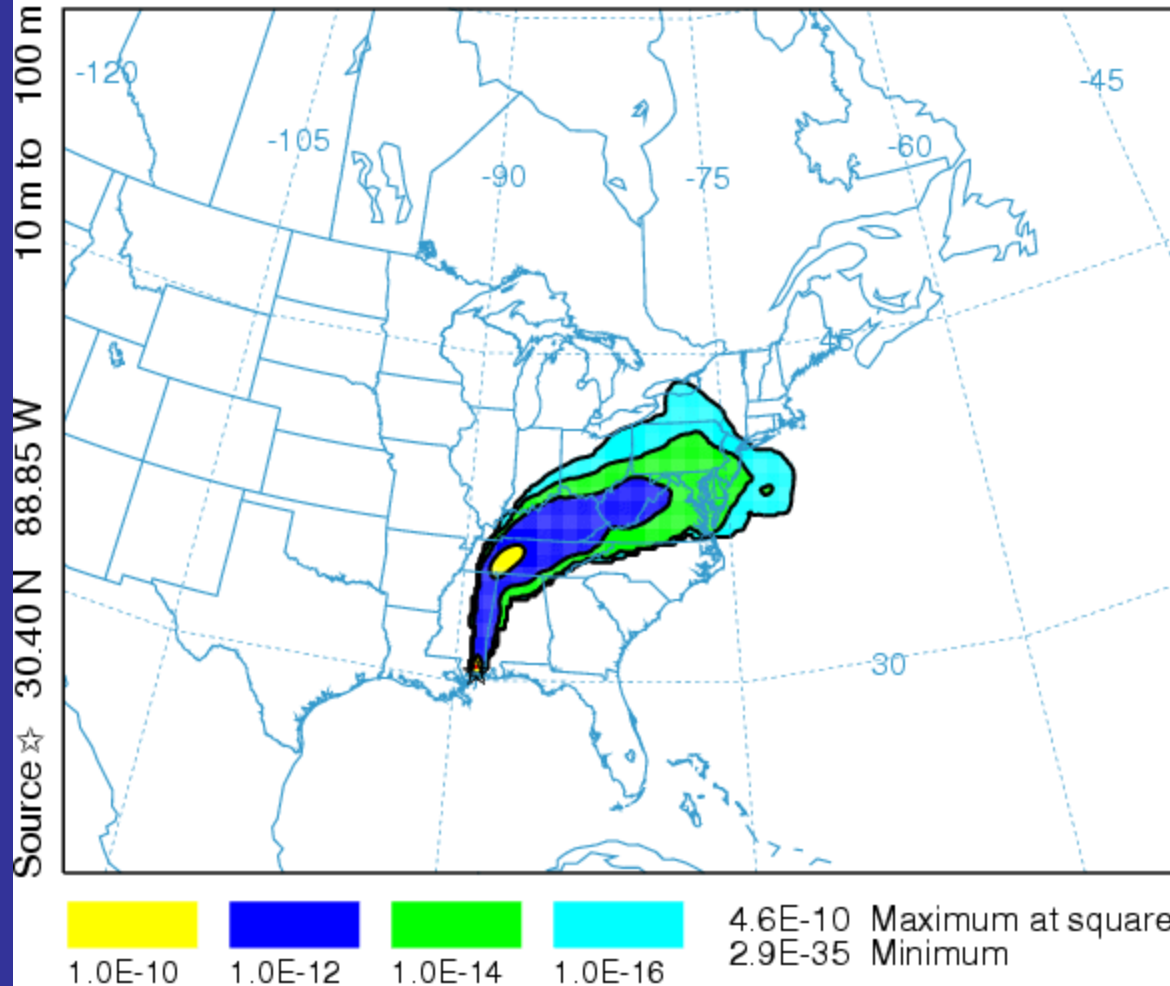


EDAS METEOROLOGICAL DATA

Job ID: 42938 Job Start: Thu Jan 22 19:00:10 GMT 2004
Source: lat.: 30.4 lon.: -88.85 Hgt: 10 to 100 m
Release ID: Rate: 2.0 unit/hr Duration: 4.0 hrs
Release Start (YY MM DD HH): 03 05 04 14
Pollutant Averaging/Integration Period: 3 hrs
Dry Deposition rate: 1 cm/s
Wet Removal (below/in-cloud): 5.0E-05 / 3.2E+05
Meteorological Data: EDAS
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL

Deposition (mass/m²) at ground-level
Integrated from 1400 04 May to 2000 05 May 03 (UTC)
Release started at 1400 04 May 03 (UTC)

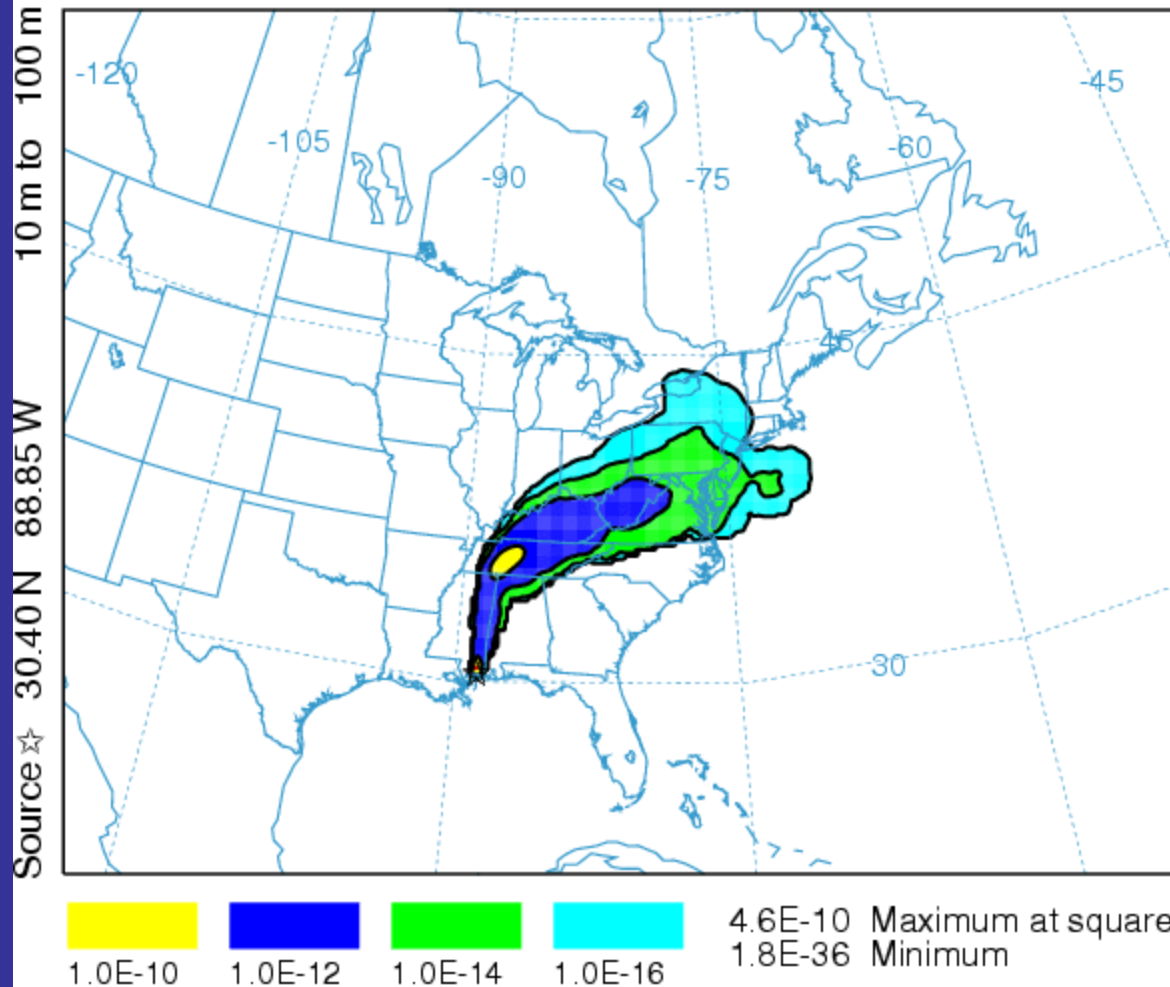


EDAS METEOROLOGICAL DATA

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Source: lat.: 30.4 lon.: -88.85 Hgt: 10 to 100 m
Release ID: Rate: 2.0 unit/hr Duration: 4.0 hrs
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Meteorological Data: EDAS
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL

Deposition (mass/m²) at ground-level
Integrated from 1400 04 May to 2300 05 May 03 (UTC)
Release started at 1400 04 May 03 (UTC)

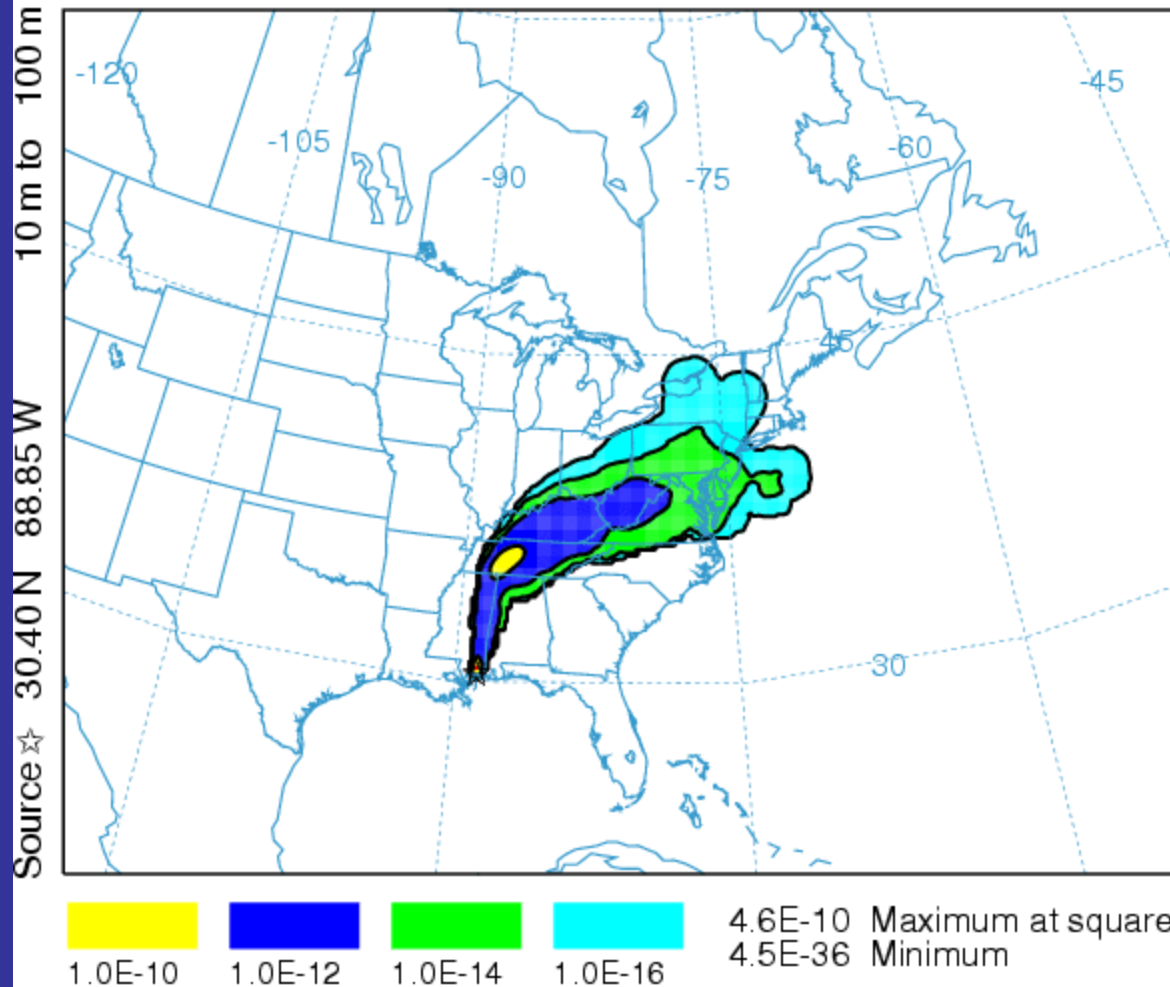


EDAS METEOROLOGICAL DATA

Job ID: 42938 Job Start: Thu Jan 22 19:00:10 GMT 2004
Source: lat.: 30.4 lon.: -88.85 Hgt: 10 to 100 m
Release ID: Rate: 2.0 unit/hr Duration: 4.0 hrs
Release Start (YY MM DD HH): 03 05 04 14
Pollutant Averaging/Integration Period: 3 hrs
Dry Deposition rate: 1 cm/s
Wet Removal (below/in-cloud): 5.0E-05 / 3.2E+05
Meteorological Data: EDAS
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL

Deposition (mass/m²) at ground-level
Integrated from 1400 04 May to 0200 06 May 03 (UTC)
Release started at 1400 04 May 03 (UTC)

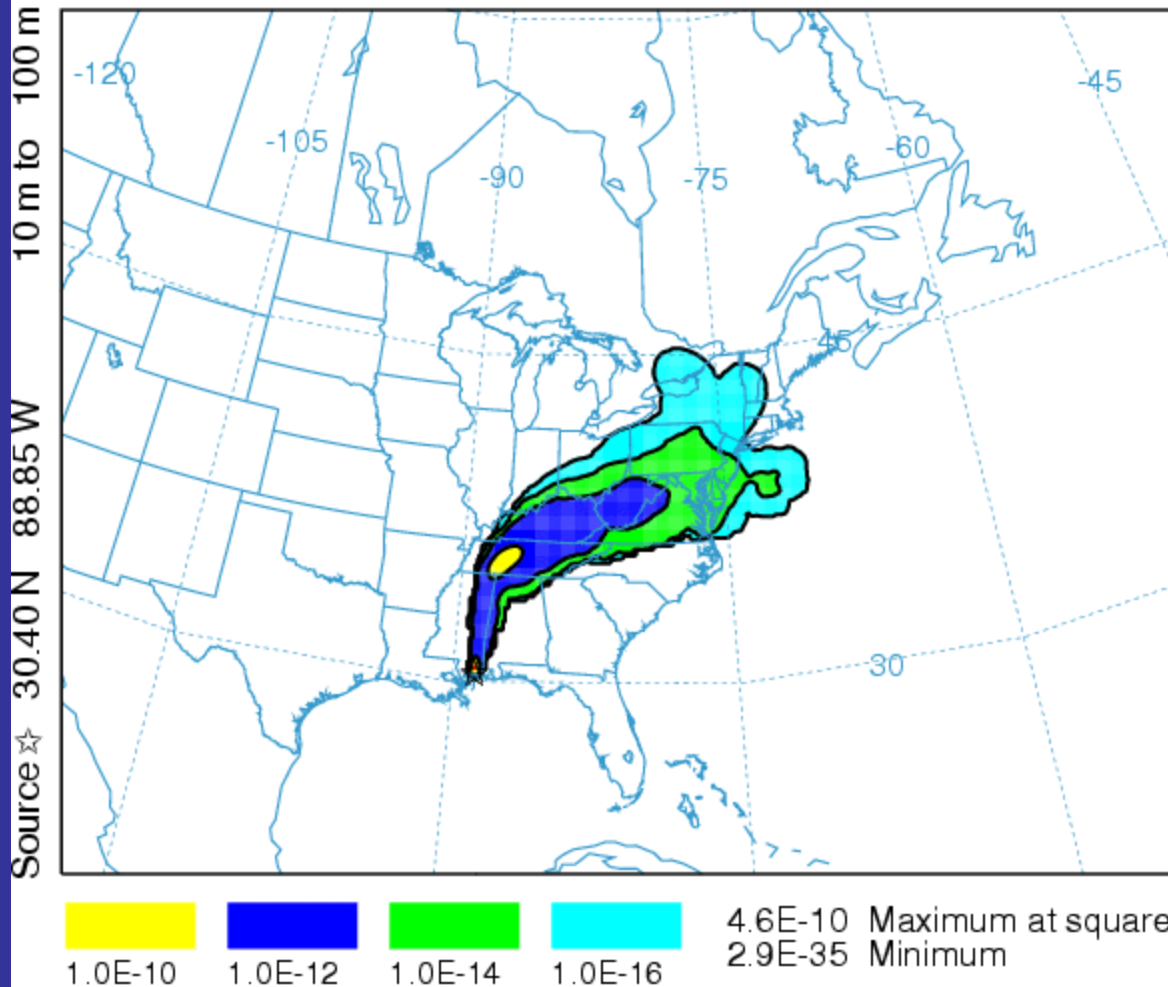


EDAS METEOROLOGICAL DATA

Job ID: 42938 Job Start: Thu Jan 22 19:00:10 GMT 2004
Source: lat.: 30.4 lon.: -88.85 Hgt: 10 to 100 m
Release ID: Rate: 2.0 unit/hr Duration: 4.0 hrs
Release Start (YY MM DD HH): 03 05 04 14
Pollutant Averaging/Integration Period: 3 hrs
Dry Deposition rate: 1 cm/s
Wet Removal (below/in-cloud): 5.0E-05 / 3.2E+05
Meteorological Data: EDAS
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL

Deposition (mass/m²) at ground-level
Integrated from 1400 04 May to 0500 06 May 03 (UTC)
Release started at 1400 04 May 03 (UTC)

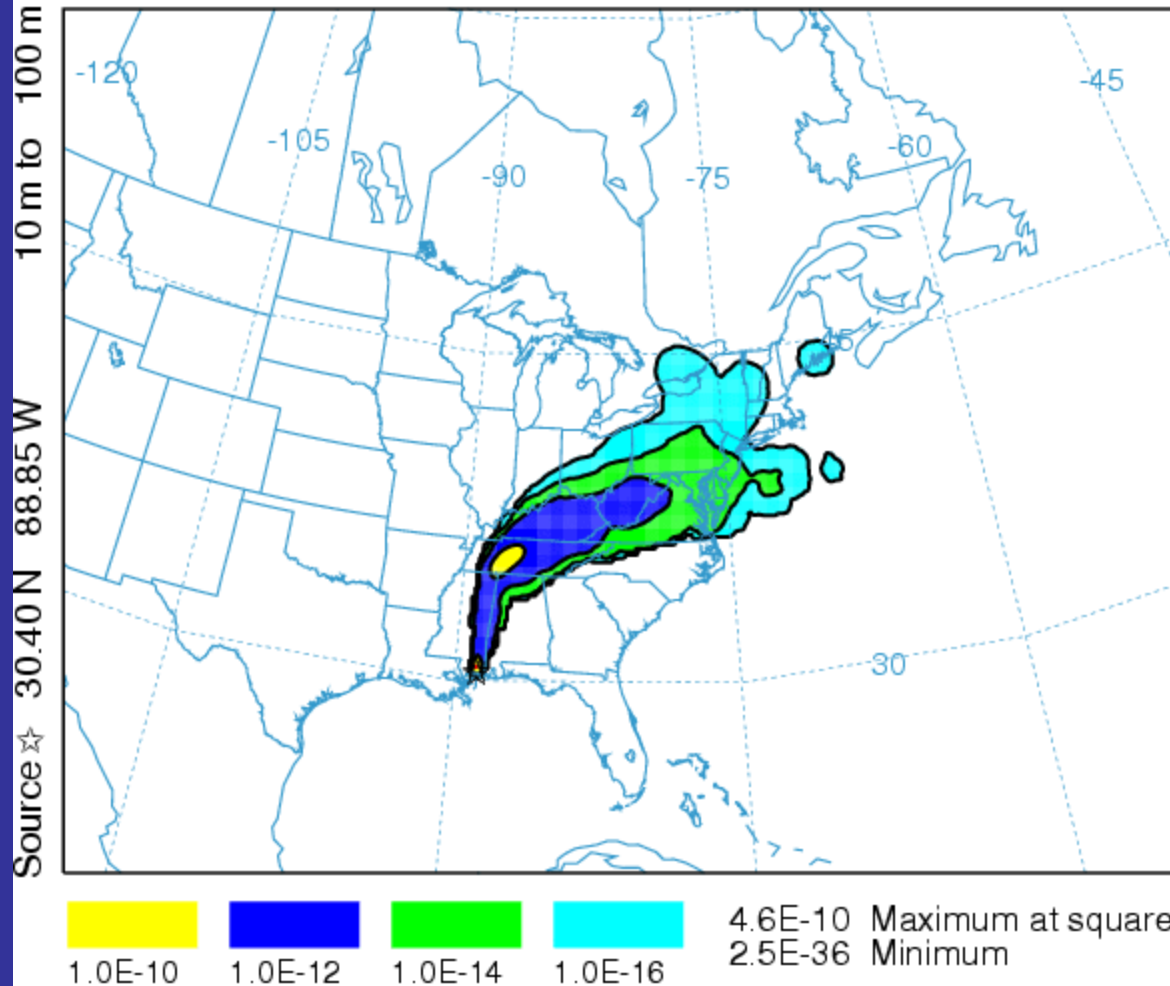


EDAS METEOROLOGICAL DATA

Job ID: 42938 Job Start: Thu Jan 22 19:00:10 GMT 2004
Source: lat.: 30.4 lon.: -88.85 Hgt: 10 to 100 m
Release ID: Rate: 2.0 unit/hr Duration: 4.0 hrs
Release Start (YY MM DD HH): 03 05 04 14
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Dry Deposition rate: 1 cm/s
Wet Removal (below/in-cloud): 5.0E-05 / 3.2E+05
Meteorological Data: EDAS
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL

Deposition (mass/m²) at ground-level
Integrated from 1400 04 May to 0800 06 May 03 (UTC)
Release started at 1400 04 May 03 (UTC)

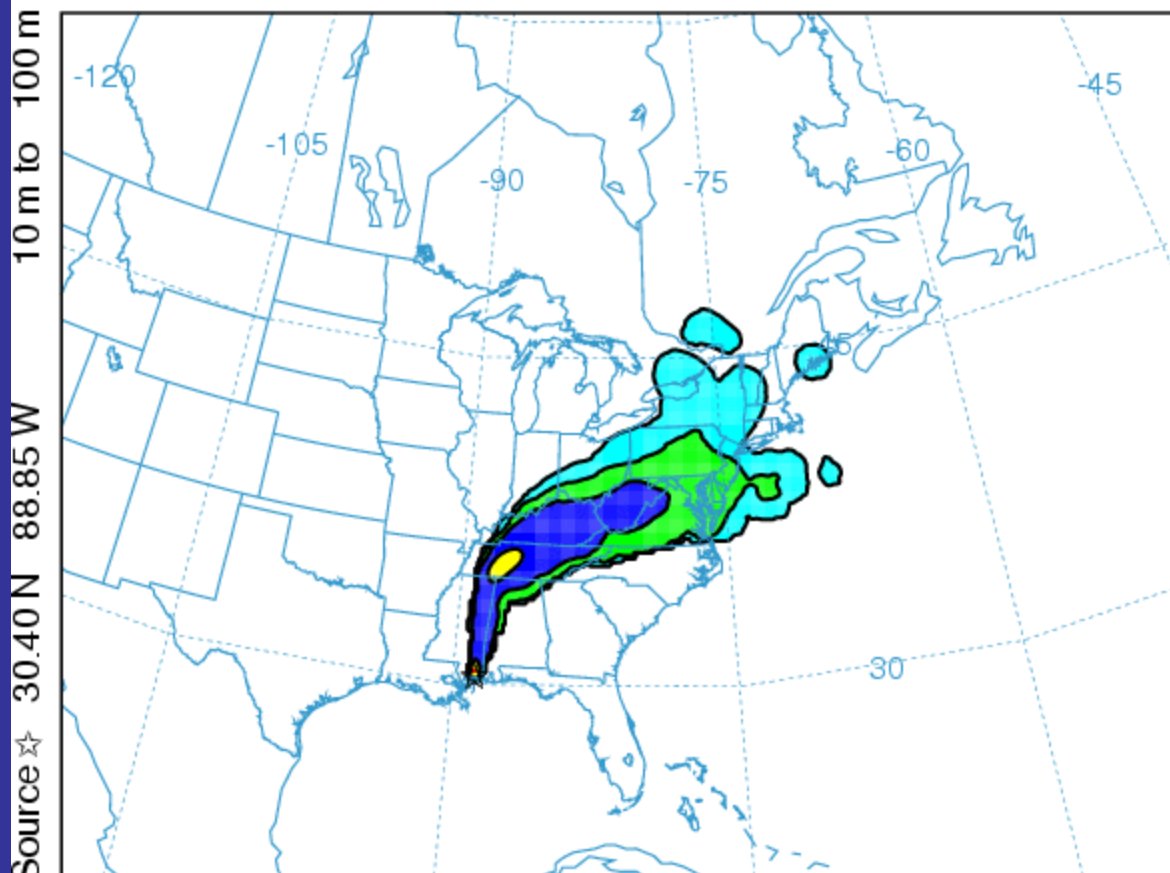


EDAS METEOROLOGICAL DATA

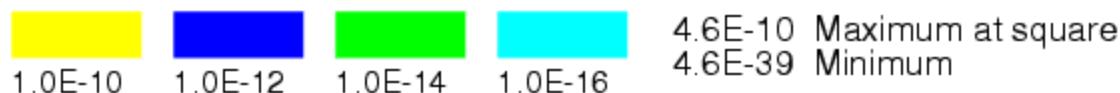
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Release ID: Rate: 2.0 unit/hr Duration: 4.0 hrs
Release Start (YY MM DD HH): 03 05 04 14
Pollutant Averaging/Integration Period: 3 hrs
Dry Deposition rate: 1 cm/s
Wet Removal (below/in-cloud): 5.0E-05 / 3.2E+05
Meteorological Data: EDAS
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL

Deposition (mass/m²) at ground-level
Integrated from 1400 04 May to 1100 06 May 03 (UTC)
Release started at 1400 04 May 03 (UTC)



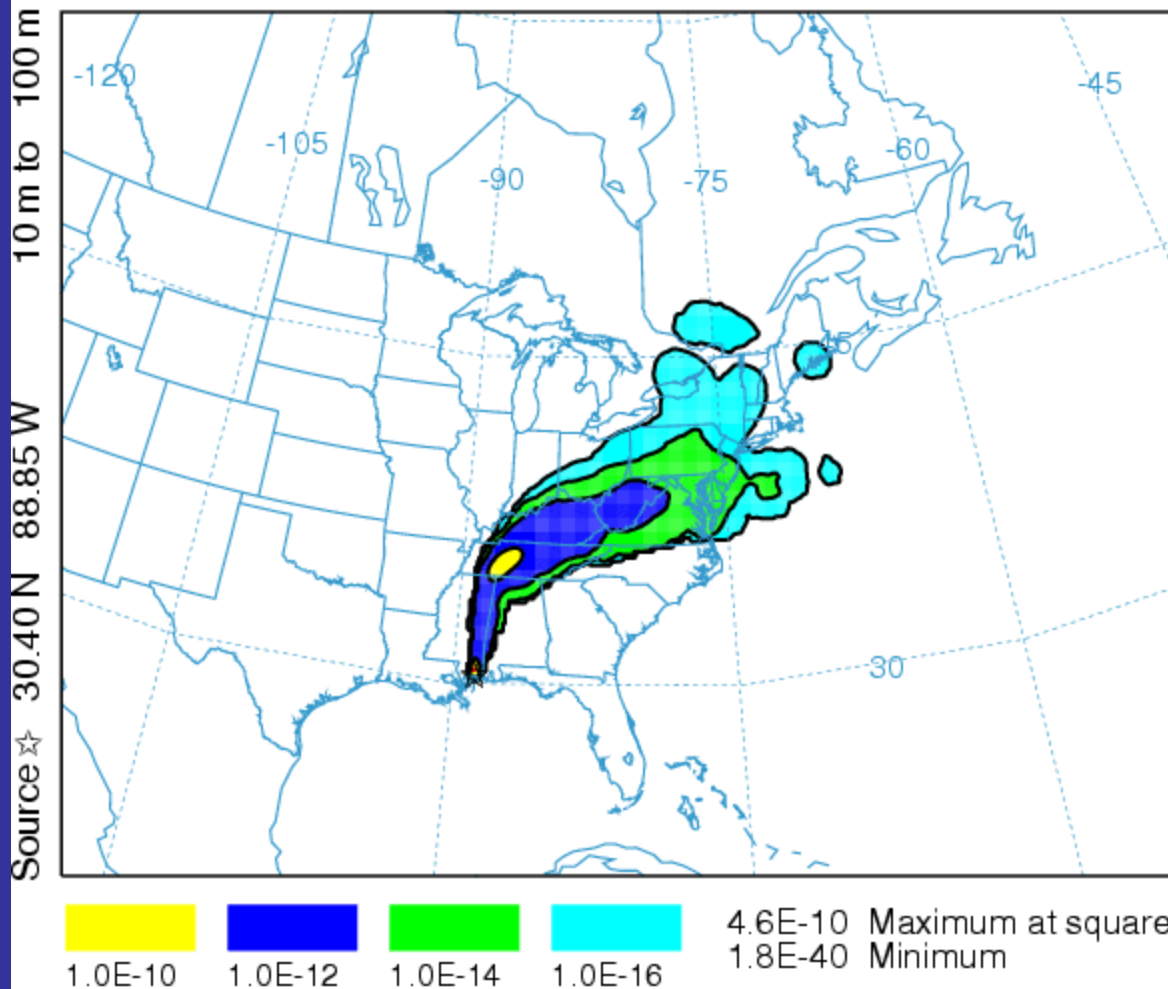
EDAS METEOROLOGICAL DATA



Job ID: 42938 Job Start: Thu Jan 22 19:00:10 GMT 2004
Source: lat.: 30.4 lon.: -88.85 Hgt: 10 to 100 m
Release ID: Rate: 2.0 unit/hr Duration: 4.0 hrs
Release Start (YY MM DD HH): 03 05 04 14
Pollutant Averaging/Integration Period: 3 hrs
Dry Deposition rate: 1 cm/s
Wet Removal (below/in-cloud): 5.0E-05 / 3.2E+05
Meteorological Data: EDAS
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL

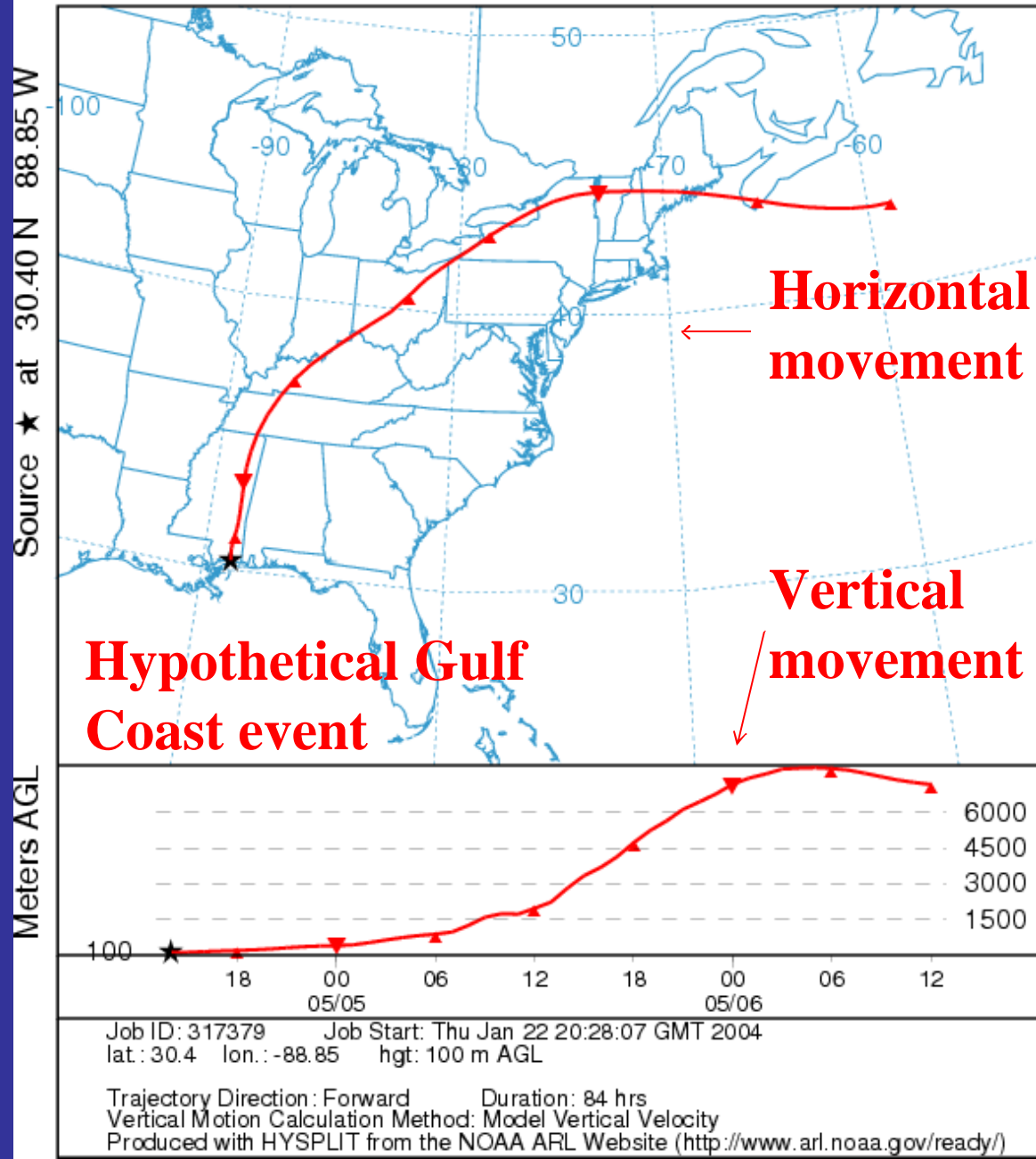
Deposition (mass/m²) at ground-level
Integrated from 1400 04 May to 1400 06 May 03 (UTC)
Release started at 1400 04 May 03 (UTC)



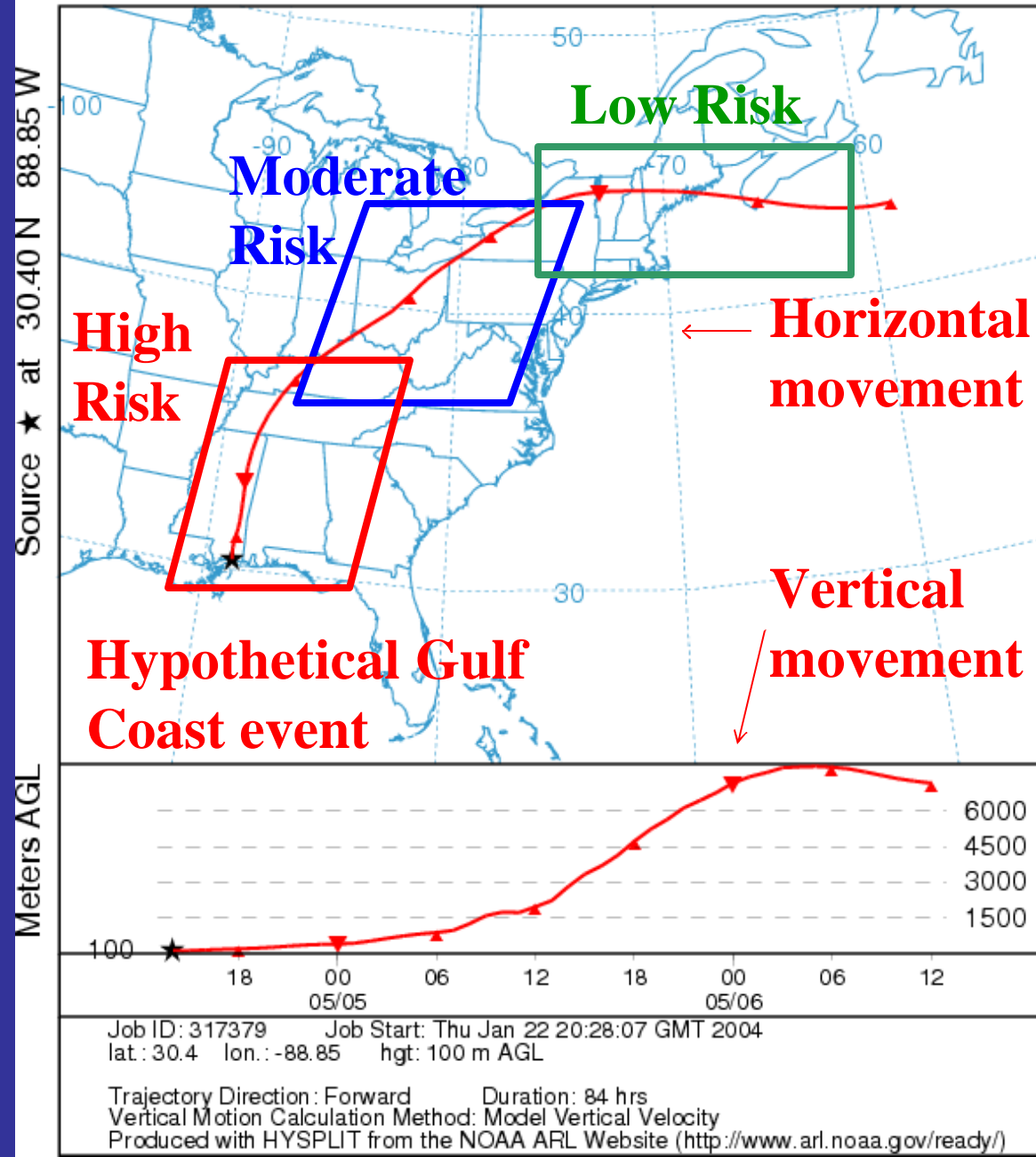
EDAS METEOROLOGICAL DATA

Job ID: 42938 Job Start: Thu Jan 22 19:00:10 GMT 2004
Source: lat.: 30.4 lon.: -88.85 Hgt: 10 to 100 m
Release ID: Rate: 2.0 unit/hr Duration: 4.0 hrs
Release Start (YY MM DD HH): 03 05 04 14
Pollutant Averaging/Integration Period: 3 hrs
Dry Deposition rate: 1 cm/s
Wet Removal (below/in-cloud): 5.0E-05 / 3.2E+05
Meteorological Data: EDAS
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL
Forward trajectory starting at 14 UTC 04 May 03
EDAS Meteorological Data



NOAA HYSPLIT MODEL
Forward trajectory starting at 14 UTC 04 May 03
EDAS Meteorological Data

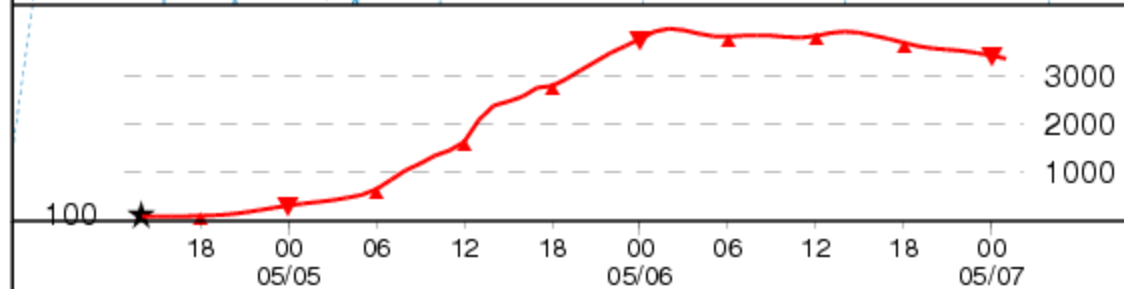
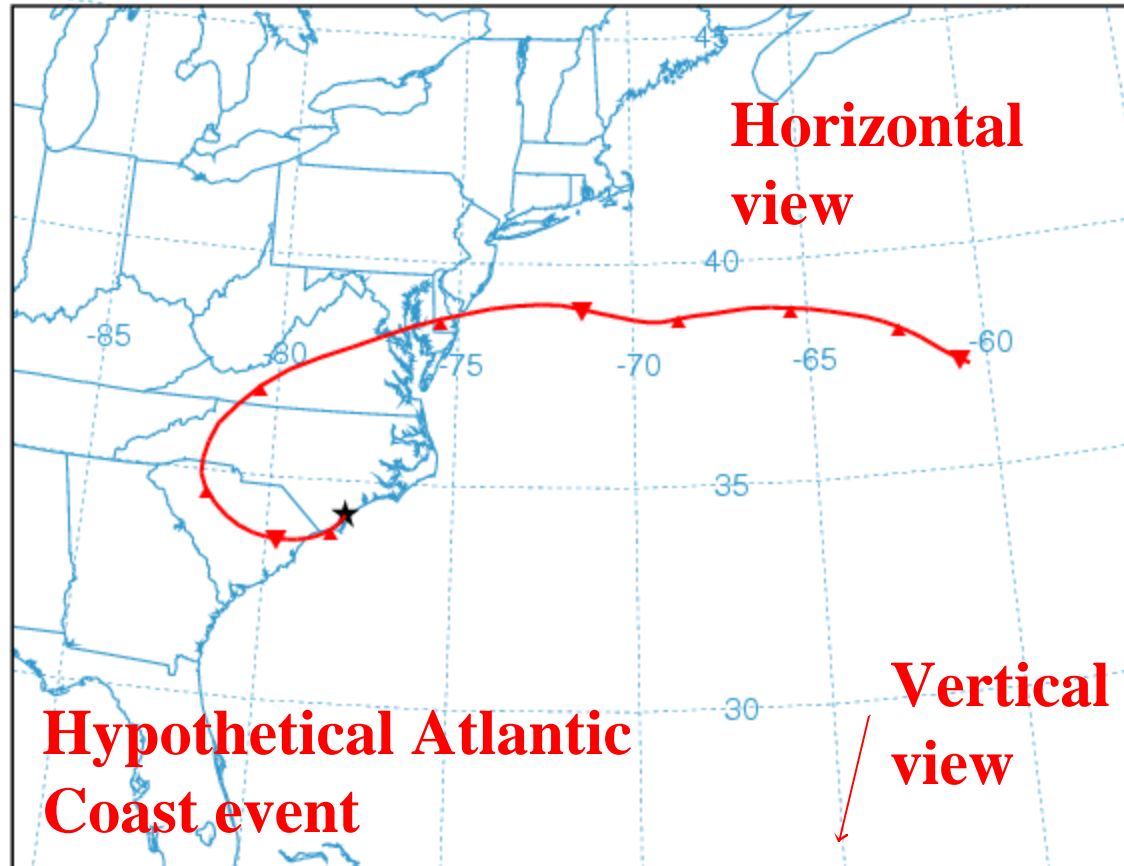


**HYPOTHETICAL TRAJECTORY AND
DISPERSION EVENT FROM THE ATLANTIC
COAST ON MAY 4, 2003 (SAME DATE)**

NOAA HYSPLIT MODEL
Forward trajectory starting at 14 UTC 04 May 03
EDAS Meteorological Data

Source ★ at 34.25 N 77.90 W

Meters AGL

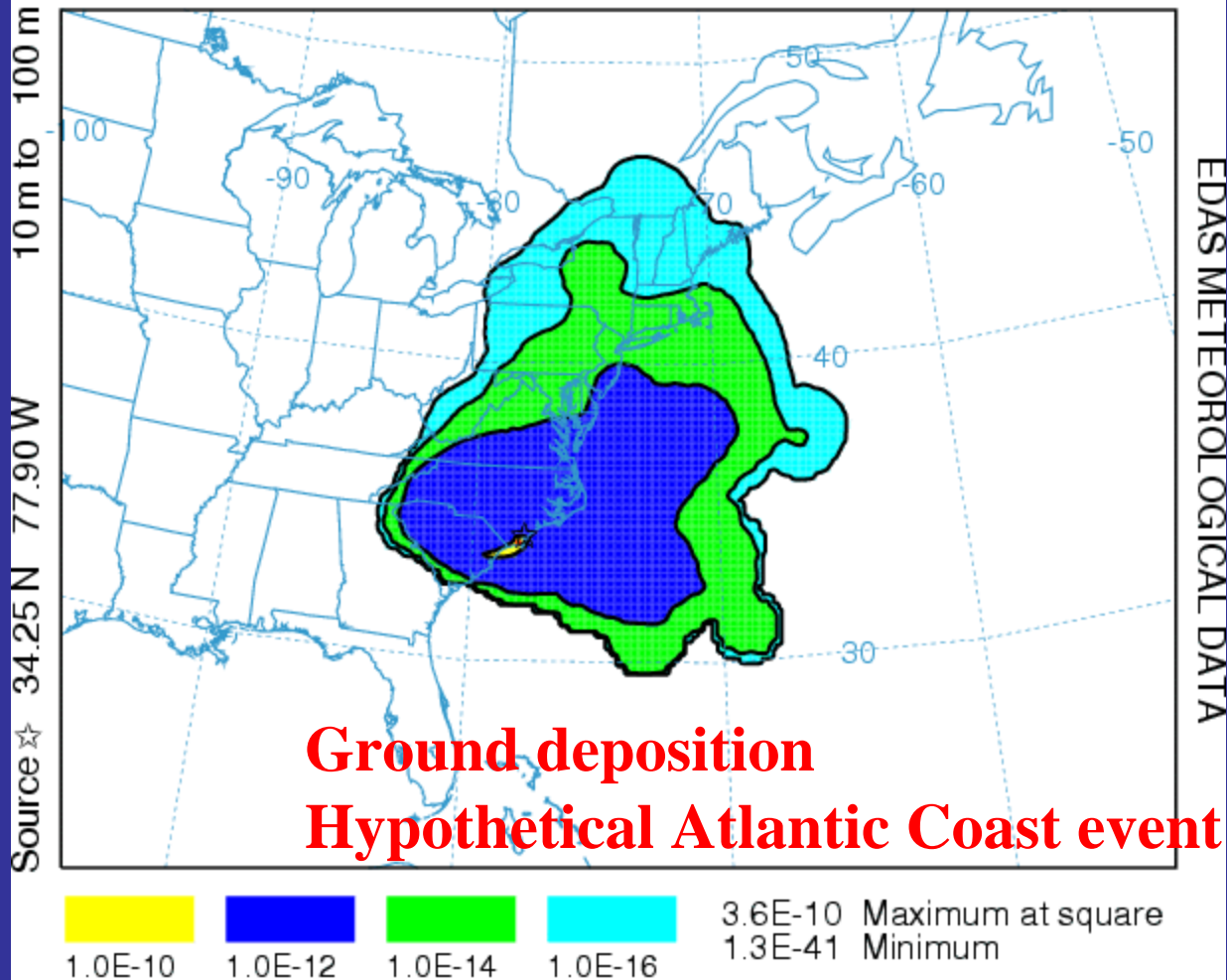


Job ID: 317317 Job Start: Thu Jan 22 20:04:27 GMT 2004
lat: 34.25 lon.: -77.9 hgt: 100 m AGL

Trajectory Direction: Forward Duration: 84 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL

Deposition (mass/m²) at ground-level
Integrated from 1400 04 May to 1400 06 May 03 (UTC)
Release started at 1400 04 May 03 (UTC)



Job ID: 42926 Job Start: Thu Jan 22 18:40:06 GMT 2004
Source: lat.: 34.25 lon.: -77.9 Hgt: 10 to 100 m
Release ID: Rate: 2.0 unit/hr Duration: 4.0 hrs
Release Start (YY MM DD HH): 03 05 04 14
Pollutant Averaging/Integration Period: 3 hrs
Dry Deposition rate: 1 cm/s
Wet Removal (below/in-cloud): 5.0E-05 / 3.2E+05
Meteorological Data: EDAS
Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

Elements of the NAPDFC Toolkit

Trajectories from NOAA'S ARL

Aerobiological and Meteorological Processes

Status of Epidemic (Location, Intensity)

Communications Network

Meteorological Data (past, present, future)

Experience

Nine Years of Producing Epidemic Forecasts via the Internet

Three Plant Disease Epidemics

> 10,000 Evaluated Transport Events

Soybean Rust - Netscape

New TabSoybean Rust

NORTH AMERICAN PLANT DISEASE FORECAST CENTER

SOYBEAN RUST

TOBACCO

CUCURBIT

SOYBEAN



[Current Forecasts](#)

[Interesting Links](#)

01/12/2005

Welcome to Soybean Rust

Welcome to the Soybean Rust Forecast homepage for 2005. The forecasts will be generated on Monday, Wednesday and Friday each week from March through October. Timely information on the occurrence of soybean rust and the future movement of inoculum (fungus spores) across the North American continent is important to soybean producers in managing this destructive and fast-moving plant disease epidemic.

Where Did It Come From?

Threat and Risks

Do You Have Soybean Rust?

Management of Soybean Rust

Reporting Soybean Rust

Report Form

* This site is still under construction. To see examples of other working sites from the North American Plant Disease Forecast Center, go to the [Tobacco Blue Mold](#) or [Cucurbit Forecast Sites](#).

**** NOTE:** These forecasts/outlooks apply ONLY to disease development from AIRBORNE TRANSPORT of spores. We do not have the capability to track soybean rust development by other means, such as transporting infected materials, or will we attempt to do so. Please consult the County Extension Service personnel in your area if you have questions about these materials.**

Disclaimer:

The forecast(s) presented in this report only represent estimates of

Start

Microsoft Po...SBR Websit...UM-Weathe...Microsoft W...SBR Websit...Soybean ...

8:34 AM

DISEASE FORECASTING WEBSITES

NCSU Soybean Rust:

www.ces.ncsu.edu/depts/pp/soybeanrust

ZedX Soybean Rust: soybeanrust.zedxinc.com

Tobacco Blue Mold:

www.ces.ncsu.edu/depts/pp/bluemold

Cucurbit Downy Mildew:

www.ces.ncsu.edu/depts/pp/cucurbit

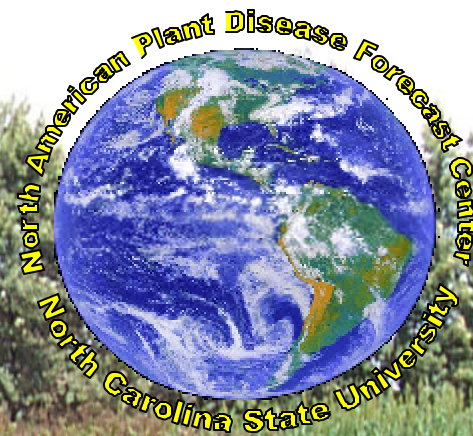
Mountain Cedar Pollen: pollen.utulsa.edu

What is Unique about the North American Plant Disease Forecast Center?

- Inter-Continental Forecasting
- State and International Reporting Network
- Forecasts Bring Together A Multitude of Necessary Components

What is Unique about the North American Plant Disease Forecast Center? (cont)

- Forecast Products are Current, and Readily Available to Growers, Industry, and Media Via the Internet and Toll-free Telephone
- All Forecasts Archived (1996 - 2004) for Reference and Educational Purposes
- Nine Years of Forecasting Experience



Let's hope and pray we won't need to use this forecasting technology for a natural event or bio-terrorism in 2005... but we are prepared!

**C.E. Main, Thomas Keever, Gerald
Holmes, Steve Koenning, Roger Magarey
February 4, 2005**

**Graphics by James Thurman
and Thomas Keever**